



NISTIR 6452

SIMnet Design and Internet Deployment Guide

Richard D. Schneeman
Computer Scientist
rschneeman@nist.gov

QC
100
.U56
NO. 6452
1999

NIST

United States Department of Commerce
Technology Administration
National Institute of Standards and Technology

NISTIR 6452

SIMnet Design and Internet Deployment Guide

Richard D. Schneeman
Computer Scientist
rschneeman@nist.gov

Sensor Integration Group
Automated Production Technology Division
Manufacturing Engineering Laboratory
National Institute of Standards and Technology

December 1999



U.S. DEPARTMENT OF COMMERCE

William M. Daley, Secretary

TECHNOLOGY ADMINISTRATION

Dr. Cheryl L. Shavers, Under Secretary of Commerce for Technology

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Raymond G. Kammer, Director

Executive Summary

Combining the power of the Internet with state-of-the-art newly emerging international multimedia standards from the International Telecommunications Union (ITU) provides a platform on which to build a next-generation, real-time collaborative metrology environment at NIST. This new Internet-based pilot Metrology system is called SIMnet after its implementation within the Interamerican Metrology System (SIM). The system is capable of allowing multiple participants over the Internet to collaborate in real-time using audio, video, chat, whiteboard, data sharing, and application sharing. The SIMnet effort led by NIST supports this capability by injecting important state-of-the-art information technology into the metrology area. In fact, by using SIMnet, the time required to complete an electrical international comparison has been reduced by a factor of 10!

In order to support these capabilities, a multipoint conferencing system was designed and built at NIST. This new system is based on international telecommunications standards and uses commercially available off-the-shelf hardware and software components. The SIMnet system is currently in use, and connects eleven national metrology centers in the Americas via the Internet to perform electrical calibration international comparisons. This document addresses the SIMnet system design including the requirements, standards, and hardware and software specifications.

After reading this document, the reader will be familiar with the software and hardware that make up the SIMnet system as well as the standards used to support the multimedia conferencing technology. This document provides important background and system information for current SIMnet users and administrators. In addition, those interested in setting up and deploying SIMnet-like environments can use this document as a comprehensive deployment guide. Finally, the document describes enough about the underlying technology of the SIMnet system to provide the reader with relevant broad-based knowledge of the technical portions of the system.

This document contains:

- An introduction to SIM and the SIMnet system.
- A description of the requirements and design that led to the SIMnet pilot system.
- The standards and technology used throughout the SIMnet definition process.
- An overview of the components and products used to realize this new system.
- Strategies for selecting the right combination of hardware and software for deployment.
- A design methodology for enhancing data-centric applications in the metrology area.
- Discussions on technical support, training, security, and firewall issues with SIMnet.
- An in-depth discussion of how to connect to and participate in the current SIMnet system.

The SIMnet design is based on rapidly evolving software, hardware, and standards. Likewise, any future SIMnet system upgrade or deployment strategy must include allowances for advances in technology. Some of these issues include using the evolving ITU multimedia standards to overcome the Internet's bandwidth limitations and security threats. Others include continued beta testing and maintenance of application software releases. All of these issues must be addressed in order to future-proof the design of the current as well as any next generation SIMnet development plan. This document concludes by capturing the technology issues that will impact any current and/or future SIMnet deployment strategy.

Acknowledgements

An effort as large as SIMnet could not be possible without the dedicated help and support of many people. We would like to take this opportunity to enumerate the outstanding contribution at many levels of the SIMnet project. Raymond Kammer, Director of NIST, Robert Hebner, former Acting Deputy Director of NIST, and Richard Jackson, Director of the Manufacturing Engineering Laboratory (MEL) at NIST all provided vision and support for the SIMnet system, and its role in advancing the international standards metrological processes.

I would also like to acknowledge the professional efforts of the eleven OAS SIMnet countries that use the SIMnet system in their work. These people were instrumental in the SIMnet Inaugural by participating in the hands-on training and demonstration, and have worked with the SIMnet system and provided feedback over the last several months.

Stephen Carpenter, the Director of the NIST International and Academic Affairs office provided international support and logistics during the entire SIMnet project. Steve is also the Chair of the Technical Committee of the SIM governing council and was instrumental in supporting this effort both at SIM and here at NIST. Also from the NIST International and Academic Affairs office, I would like to thank Marian McCurley and Claire Saundry for their assistance during the SIMnet effort.

The success of the SIMnet Inaugural demonstration in December of 1998 was due to the efforts of many contributors including William Anderson, Chief of the Electricity Division in the Electrical and Electronics Engineering Laboratory (EEEL) for supporting this state-of-the-art effort. Nile Oldham and Mark Parker from EEEL's Electricity Division took the first steps in testing and promoting the use of Internet-based electrical measurement processes. Their initial work in this area, and collaborators in Canada (Peter Filipski) and Mexico (Oscar Gutierrez) has led to the development of the SIMnet system.

Clayton Teague, Chief of the Automated Production Technology Division (APTD) of MEL and Kang Lee, Group Leader, also of APTD provided support for this effort and reviewed this document. Richard Schneeman, a Computer Scientist from APTD was the principal SIMnet designer and author of this document. Mark Luce, Division Chief of the Office of Manufacturing Programs, and Raymond Hoffmann and Rob Densock of the MEL Systems Administration (MELSA) Group for providing network and computer technical support.

Mark Bello and Jan Hauber from the NIST Public and Business Affairs office provided the public relations information that was critical in getting the SIMnet message out to the public. They provided press releases, copy information, and logistics to the SIMnet effort.

The NIST Conference Facilities personnel of Dean Smith, Ray Natoli, and especially Hoyt Cox spent many hours working with SIMnet staff in order to make the presentation of the SIMnet system a success.

Contents

EXECUTIVE SUMMARY	3
ACKNOWLEDGEMENTS	5
1 INTRODUCTION.....	11
1.1 SIMNET INAUGURAL	12
1.2 CURRENT SIMNET APPLICATION	13
1.3 SIMNET DESIGN DOCUMENT STRUCTURE	14
2 SIMNET OVERVIEW	15
2.1 INTERNET-BASED VIDEOCONFERENCING	15
2.2 SIMNET TOPOLOGY	17
2.3 H.323 STANDARDS-BASED ARCHITECTURE.....	19
2.4 SIMNET COLLABORATIONS	20
3 SIMNET REQUIREMENTS	22
3.1 SYSTEM REQUIREMENTS.....	22
3.2 ADDITIONAL REQUIREMENTS	24
3.2.1 <i>Broadcast and Multicast Issues</i>	24
3.2.2 <i>Experience with Microsoft NetMeeting</i>	25
3.2.3 <i>Multipoint Control Unit (MCU) Capabilities</i>	26
4 SIMNET DESIGN.....	27
4.1 CLIENT-SERVER DESIGN.....	27
4.2 DESIGN ISSUES.....	29
4.3 SIMNET SERVER	30
4.3.1 <i>SIMnet Server Software</i>	30
4.3.2 <i>SIMnet Server Hardware</i>	34
4.4 SIMNET CLIENTS.....	37
4.4.1 <i>SIMnet Client Software</i>	38
4.4.2 <i>SIMnet Client Hardware</i>	44
5 SIMNET PILOT SYSTEM	51
5.1 TEAMING	51
5.2 SPECIFICATIONS.....	52
5.2.1 <i>Hardware</i>	52
5.2.2 <i>Software</i>	55
5.2.3 <i>Ancillary Hardware and Software</i>	56
5.3 STAGING AND CONFIGURATION	56
5.3.1 <i>Staging</i>	57
5.3.2 <i>Configuration</i>	57
5.4 TESTING.....	61
6 SIMNET SUPPORT	63
6.1 TRAINING.....	63
6.1.1 <i>SIMnet Training for Administrators</i>	63
6.1.2 <i>SIMnet Training for Metrologists</i>	64
6.2 TECHNICAL SUPPORT	65
6.2.1 <i>Hardware Support</i>	65
6.2.2 <i>Software Support</i>	65
6.2.3 <i>Identifying Client Bandwidth Constraints</i>	67
6.2.4 <i>Performance Monitoring</i>	68
6.3 INFORMATION DISSEMINATION.....	71

6.3.1	<i>SIMnet Web Site</i>	71
6.3.2	<i>Email Support</i>	72
6.3.3	<i>Frequently Asked Questions (FAQ)</i>	72
6.3.4	<i>Lessons Learned from User Feedback</i>	73
7	FUTURE ISSUES	74
7.1	CASCADING SIMNET SERVERS	74
7.2	SECURITY	77
7.2.1	<i>Inherent H.323 Security</i>	78
7.2.2	<i>SIMnet Client Application Security</i>	78
7.2.3	<i>User Access Control</i>	79
7.3	CONTINUED BETA TESTING	82
7.4	H.323 CLIENT APPLICATION UPDATES	83
7.5	THE NEXT STEP: TOWARD IMPLEMENTING SIMNET2.....	85
	BIBLIOGRAPHY	90
	ABBREVIATIONS AND ACRONYMS	91
	APPENDIX A: USING NETMEETING 2.11 TO CONNECT TO A SIMNET CONFERENCE	92
	APPENDIX B: HARDWARE AND SOFTWARE SPECIFICATIONS	95

Disclaimer

Certain commercial equipment, instruments, or materials are identified in this paper to specify the experimental procedure adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

List of Figures

Figure 1: The 34 member nations of the OAS that make up the five SIM subregions.....11

Figure 2: Display during a completed international comparison between NIST and Argentina.....13

Figure 3: Videoconferencing using a point-to-point connection on the Internet.....16

Figure 4: Videoconferencing using a multipoint connection environment on the Internet.....17

Figure 5: The SIMnet topology can support a variety of communication pathways.....18

Figure 6: The ITU H.323 Standards-based Architecture.....19

Figure 7: Participants in SIMnet using real-time audio, video, and application sharing.....21

Figure 8: The SIMnet architecture uses a client-server design.....28

Figure 9: The SIMnet server requirements definition process.....29

Figure 10: Web Center is PictureTel's Web-based remote administration facility.....33

Figure 11: The user interface of the PictureTel 330 NetConference Administration Console.....34

Figure 12: The Microsoft NetMeeting Support for the H.323 Architecture.....38

Figure 13: NIST calibration system can be used during SIMnet to verify DMM calibrations.....42

Figure 14: The user interface of Symantec's pcAnywhere.....43

Figure 15: The Winnov Videum AV PCI videoconferencing board and camera set.....47

Figure 16: The Andrea Electronics NC-65 computer-based headset used in SIMnet.....48

Figure 17: The National Instruments IEEE-488 GPIB hardware board for Windows NT.....49

Figure 18: A typical DMM testing setup at NIST using HP and Fluke equipment.....50

Figure 19: The SIMnet server specifications obtained from the DELL Web Site.....53

Figure 20: The SIMnet Client Specifications from the DELL Web Site.....54

Figure 21: NetTach is used to determine available bandwidth for videoconferencing.....67

Figure 22: Using Windows NT Diagnostics Tool to resolve hardware conflicts.....69

Figure 23: Using Performance Monitor to optimize the Windows NT environment.....70

Figure 24: The NIST SIMnet Web Site provided by EEEL.....72

Figure 25: The centralized SIMnet server hosts multiple Internet connections.....75

Figure 26: A cascaded design reduces overall traffic between servers by using one connection.....76

Figure 27: The location of the SIMnet server in relation to the NIST firewall.....80

Figure 28: Microsoft NetMeeting version 2.11 is currently used in the SIMnet system.....83

Figure 29: The new user interface of Microsoft Windows NetMeeting™ 3.01.....84

Figure 30: Cascading provides a hybrid client-server configuration for SIMnet2.....87

1 Introduction

SIMnet represents a pilot project developed at the National Institute of Standards and Technology (NIST) that interconnects eleven national metrology laboratories of the Americas over the Internet. The SIMnet system uses a centralized server platform that provides a standards-based multipoint conferencing environment for SIMnet participants to initially conduct collaborative electrical quantity measurement and international comparison sessions using the Internet.

The Interamerican Metrology System (SIM)¹ was the result of an agreement between the national metrology organizations from the 34 member nations of the Organization of American States (OAS), shown in Figure 1.

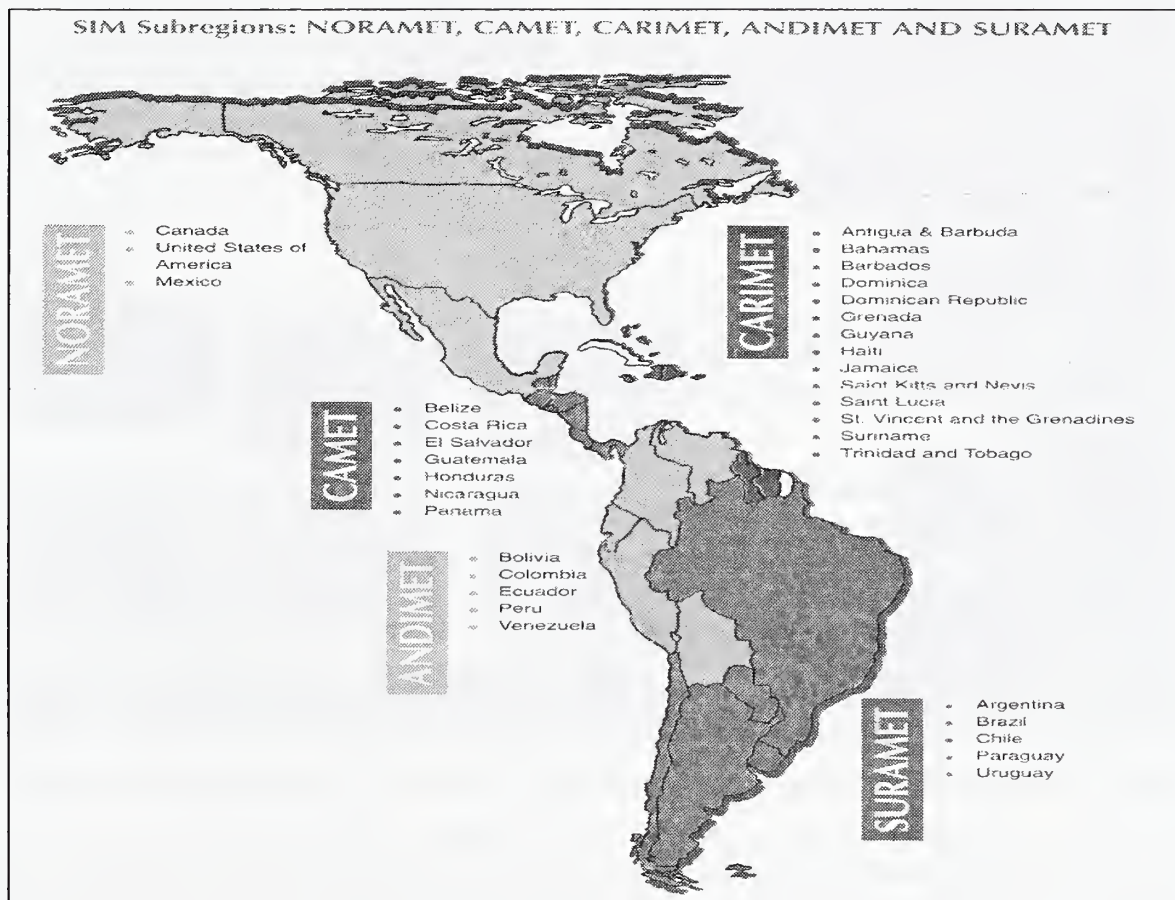


Figure 1: The 34 member nations of the OAS that make up the five SIM subregions.

The SIMnet system derives its name from SIM, the regional metrology organizational structure for the Americas. The SIM acronym was combined with “*net*” to indicate an Internet-based solution that facilitates collaboration among the OAS member nations. SIM was created to promote international, interamerican, and regional cooperation in metrology. The SIM is committed to implementing a Global Measurement System within the Americas that ensures confidence among

¹ The SIM acronym is derived from the Spanish translation of the Interamerican Metrology System, or the Sistema Interamericano de Metrologia.

all its users. The five subregions of SIM including NORAMET, CARIMET, CAMET, ANDIMET, and SURAMET are comprised of 34 countries from the Americas. NIST is a member of NORAMET, representing the United States. The SIM agreement is essential for allowing the establishment and development of a significant regional measuring system. More importantly, SIM will help to break down the barriers to free trade in the Americas by establishing equivalence among national standards and certificate issuing metrology laboratories.

Measurement metrology throughout the Americas can be enhanced with higher degrees of speed, quality, accuracy, timeliness, and fairness through the use of an Internet-based real-time collaborative environment. In fact, when using conventional methods and procedures, performing electrical international comparisons between two metrology centers used to take 6 months to complete. Using the SIMnet system, these same international comparisons can be obtained and completed in substantially less time.

SIMnet also helps to train scientific and technical personnel, collect and distribute technical and scientific documentation, and maintain linkages with the international standards maintained by the International Bureau of Weights and Measures (BIPM). The SIMnet effort led by NIST supports the maintenance of a consistent measuring system by injecting state-of-the-art information technology into the metrology area.

1.1 *SIMnet Inaugural*

On December 4, 1998, the SIMnet Inaugural was held at NIST to showcase the completion of the SIMnet system. VIPs attended the demonstration of the SIMnet pilot program from NIST, and dignitaries from both the OAS organization and each of the 12 member countries participating in the event².

The Inaugural featured speeches from both NIST and SIM personnel, followed by a real-time online demonstration highlighting the capabilities of the SIMnet system. The demonstration consisted of having 12 SIMnet client systems located on the NIST campus network manned by a SIMnet team from each country. Each team connected into one large virtual SIMnet conference room using their SIMnet client computers. The conference was displayed live from a video projector system that was connected to a demonstration computer in the Green auditorium at NIST. During the conference, the real-time audio, video, and application sharing features of the system were demonstrated to the audience. Each respective member country was then asked to introduce themselves, demonstrating the interactive audio and video capabilities from each of the 12 clients.

The SIMnet teams from the 12 member countries participating in the Inaugural had completed two-days of hands-on and classroom instruction on the details of the SIMnet system, including the use of metrology applications and system administration training. After the event, the machines were disassembled and shipped to their respective countries to be used in the field for official SIMnet international comparisons.

The SIMnet Inaugural was deemed very successful. The SIMnet participants, the project, and demonstration received a great deal of adulation from the SIM organization, dignitaries of the member countries, and NIST officials.

² The twelve participating nations in the SIMnet trial and demonstration at NIST include: Argentina, Brazil, Canada, Colombia, Costa Rica, Ecuador, Jamaica, Mexico, Panama, Trinidad and Tobago, the United States, and Uruguay.

1.2 Current SIMnet Application

The SIMnet system has officially been deployed and is currently being used to support electrical international comparisons between various regions of the OAS. It is expected that the SIMnet capability will be used to provide similar international comparisons in the mass, chemical, and eventually the force areas of standards metrology. In the meantime, the SIMnet system is being used frequently for official international comparisons, ad hoc sessions, knowledge transfer, and training.

Figure 2 illustrates a screen image of an electrical international comparison session between NIST (from NORAMET) and Argentina (from SURAMET) completed in March of 1999. In Figure 2, we see a typical screen image that a user participating in a SIMnet international comparison session might see.



Figure 2: Display during an international comparison between NIST and Argentina.

The graphical display in Figure 2 illustrates how to physically connect the device under test to the calibrator. The host country captured the image showing the connection during the SIMnet session. The remote site views the image and directions to ensure a valid connection of their equipment. A shared application executes and collects measurement data in the background for use during the international comparison. During a SIMnet session, all participants in the meeting see and hear the same thing simultaneously. The real-time audio and video sequences are supported by collaborative tools such as a whiteboard, chat, file transfer, and most importantly the ability to share applications in real-time over the Internet. These tools are used together to provide a collaborative Internet-based metrology environment for the Americas.

1.3 *SIMnet Design Document Structure*

The *SIMnet Design and Internet Deployment Guide* is structured to provide the reader with a solid understanding of the SIMnet requirements, design, architecture, implementation, and support efforts. In Section 2, we provide an overview of Internet-based videoconferencing, the SIMnet topology, standards, and the current use of the SIMnet system. Section 3 details the complete background on the requirements for the SIMnet system definition. Section 4 highlights the client-server design of the SIMnet system. Section 5 details the SIMnet testbed and the components of the SIMnet system. A detailed list of software and hardware components is presented in Section 5. Section 6 provides information about the specific procedures NIST developed to deploy and support the SIMnet system in the field. Section 7 concludes the document with a discussion on technology advances that will impact the current SIMnet system maintenance strategy. We close with a discussion on important technology issues and changes affecting future SIMnet system design and development activities.

2 SIMnet Overview

SIMnet provides videoconferencing services over the Internet. In addition to the audio and video capability, SIMnet provides several unique data-centric applications such as whiteboard, chat, file transfer, and application sharing capabilities. These applications provide a unique environment for multiple participants to collaborate in real-time using the Internet. We use the term “collaborate” to refer to the simultaneous use of real-time audio, video, whiteboard, chat, and application and data sharing capabilities during an Internet session. The SIMnet system development was driven by the requirement for metrologists to collaborate in real-time on international comparison efforts among OAS member nations.

SIMnet leverages several newly emerging international multimedia and communications standards from the International Telecommunications Union (ITU) to provide collaborative multimedia services over an Internet Protocol (IP) based network³. The SIMnet solution uses state-of-the-art, off-the-shelf hardware and software systems that implement the ITU H.323 multimedia conferencing standards for the Internet. Companies such as Microsoft, Intel, and PictureTel to name a few are currently supporting the H.323 standards in their Internet-based videoconferencing products.

This SIMnet overview contains four subsections. Subsection 2.1 provides a brief historical overview of videoconferencing techniques and standards. Subsection 2.1 concludes with a description of Internet-based videoconferencing techniques for point-to-point and multipoint connections. Subsection 2.2 describes the SIMnet topology augmented with standards to provide simultaneous real-time videoconferencing to multiple parties. Subsection 2.3 provides a general overview of the H.323 standards architecture and its relationship to the SIMnet topology. Finally, Subsection 2.4 describes how SIMnet is used as part of the ongoing collaborations with OAS member countries in the electrical standards measurement domain.

2.1 Internet-based Videoconferencing

The technology required for conducting videoconferencing has existed for over a decade. Videoconferencing technology began with very expensive group conferencing systems that were designed to send and receive compressed audio and video over communications endpoints which provided a guaranteed or predictable bandwidth allocation scheme (i.e., point-to-point T1, fractional T1, or the integrated services digital network (ISDN)). The standards for connecting to the conference, compressing audio/video, and performing error control were just beginning to emerge and are known today as H.320. These systems were not fully interoperable because implementations were based on highly proprietary solutions. These systems used telephony-based circuit-switched networks exclusively and were therefore extremely expensive to operate. Special rooms were required that provided the hardware, software, and communications infrastructure needed to support videoconferencing. This effectively resulted in shutting out a large number of possible users from participating in this exciting collaborative technology.

As with many technology areas, the above restrictions weakened as the technology became less expensive to manufacture. More importantly, ubiquitous packet-switched data networks based on

³ For more information about the International Telecommunications Union (ITU) or the H.323 standards available from them, please reference the following Web locations: <http://www.itu.int/> and <http://www.itu.int/itudoc/itu-t/h/h323.html>, respectively.

the Transmission Control Protocol/Internet Protocol (TCP/IP), such as the Internet, provided much less expensive and considerably more flexible connectivity options than telephony-centric networks. In addition, a key standard emerged for supporting audio and video conferencing over networks based on TCP/IP. This of course is the new ITU H.323 standards that are just starting to appear in conferencing products for the Internet. SIMnet leverages these newly emerging H.323 standards to provide a collaborative, real-time conferencing and data/application sharing environment using cost-effective PC-based videoconferencing equipment with the Internet.

Most off-the-shelf applications for video or teleconferencing over the Internet use a point-to-point connection strategy. The point-to-point topology is shown in Figure 3. User A, an H.323 client, such as Microsoft NetMeeting calls User B (also a H.323 client) by using the Internet Address of User B's system⁴.

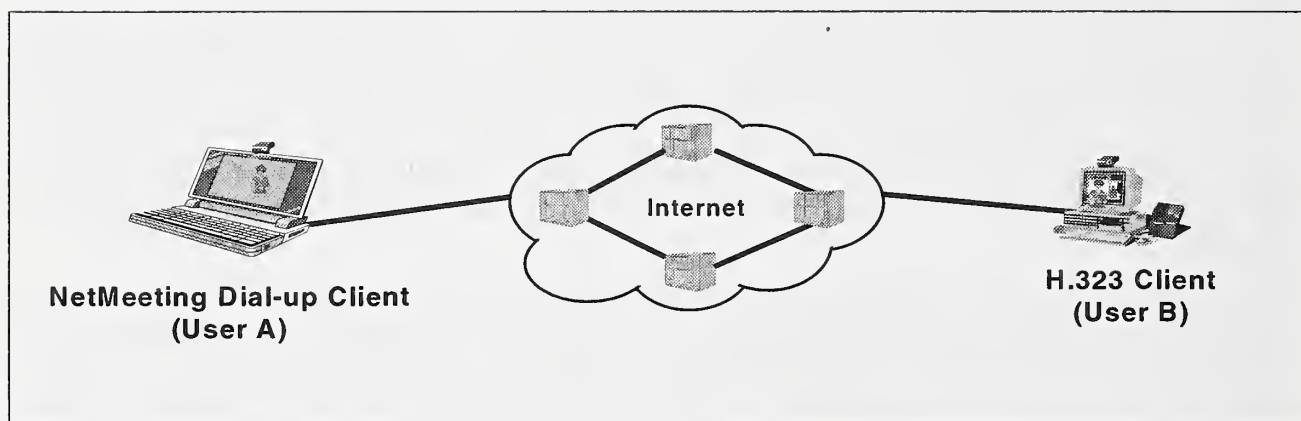


Figure 3: Videoconferencing using a point-to-point connection on the Internet.

User B receives an incoming call from User A and the two begin a two-way point-to-point communication session. Notice that this scenario represents a point-to-point connection and does not allow more than two parties to interact as if they were participating in a more traditional telephony-based multi-way videoconference. This scenario can support application, whiteboard, chat, and data sharing capabilities to more than two members. However, the audio and video data streams cannot be replicated to more than two members at any given time. This is because NetMeeting does not inherently support multi-way audio and videoconferencing capabilities without a specialized server component.

In the design of the SIMnet system, our principal goal was to find a way to support the complete functionality of an H.323 compliant client such as NetMeeting (i.e., audio, video, and data sharing), while also supporting more than two concurrent users in a conference. The H.323 standards support this capability by defining a “multipoint” conferencing concept. An implementation of the multipoint concept is realized in what is termed a multipoint control unit (MCU). In order to support the multipoint concept in SIMnet, we researched how to extend multipoint control unit capabilities to H.323 clients in the field. Our solution is based on combining an H.323 multipoint control unit-based conferencing server located at NIST, with geographically disperse H.323 clients in the field that are capable of connecting to it.

⁴ In most H.323 client applications, addressing participants can be achieved in many ways. Using an Internet address is one example. Other methods include using a naming service such as the Lightweight Directory Access Protocol (LDAP), email addresses, or telephony-based H.320 endpoints.

The SIMnet system operates in a multipoint star configuration and provides a centralized facility for remote participants to “call” into using the Internet. The addition of a multipoint conferencing server is what differentiates this particular conferencing system from mainstream point-to-point Internet conferencing approaches. The SIMnet multipoint topology is shown in Figure 4. Users A, B, and C for example, would participate in a collaborative session using SIMnet by *calling* into the H.323 MCU-based conferencing server located at NIST to join a conference.

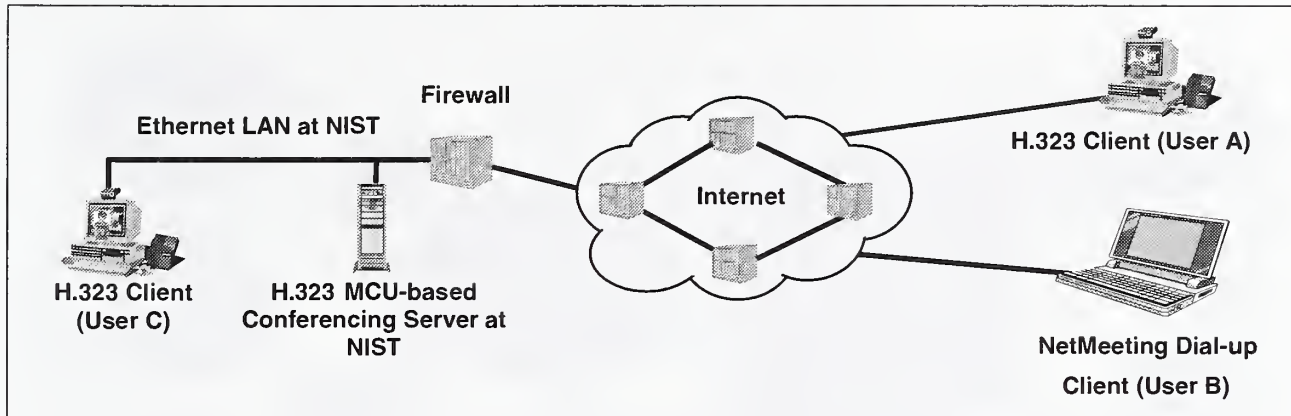


Figure 4: Videoconferencing using a multipoint connection environment on the Internet.

Upon successful connection to the meeting on the server, all participants in the SIMnet conference are then free to communicate with each other. The SIMnet server supports multiple concurrent users from the OAS member nations and provides the simultaneous real-time audio, video, whiteboard, chat, and data and application sharing capabilities that are inherent in H.323 clients such as Microsoft NetMeeting. Using SIMnet, clients simultaneously view the applications that support the electrical measurement and calibration international comparison sessions. The ability to share applications in real-time with all conference participants is critical to SIMnet and is what makes this multipoint videoconferencing server configuration unique.

2.2 SIMnet Topology

Figure 5 illustrates the complete Internet-based network and computer communication capabilities of the SIMnet system. The NIST Intranet portion of the topology shown on the left in Figure 5 was exercised during the SIMnet Inaugural demonstration. The 12 SIM participants (i.e., OAS1 through OAS12) were located at NIST and connected via a local area network (LAN) to the H.323/T.120 MCU-based conferencing server. The OAS participants were located at NIST in two separate conference rooms using the exact hardware and software that would be shipped to each of their respective countries.

During normal SIMnet operations, OAS participants connect to the MCU from their home countries using a variety of Internet-based connectivity options as the SIMnet topology in the right side of Figure 5 suggests. During SIMnet sessions, metrologists located on the NIST LAN-based Intranet interact with OAS participants over the Internet using the multipoint conferencing server.

The versatility of the Internet and the H.323 protocols can be seen in Figure 5 by the variety of methods that can be used to participate in the SIMnet collaborative meetings. The integrated services digital network (ISDN) can be used via the use of a H.320 gateway to access the Internet

and more importantly the SIMnet server. All audio and video capabilities of ISDN-based videoconferencing equipment can be used in the SIMnet configuration providing unparalleled access from a variety of communication equipment. Finally, if OAS members or others want to simply listen and talk during the SIMnet session, a capability exists to link up the public switched telephone network (PSTN) to the conference using an H.323 gateway. With this capability, anyone using an analog telephone can dial into the SIMnet conference to listen or speak during the session.

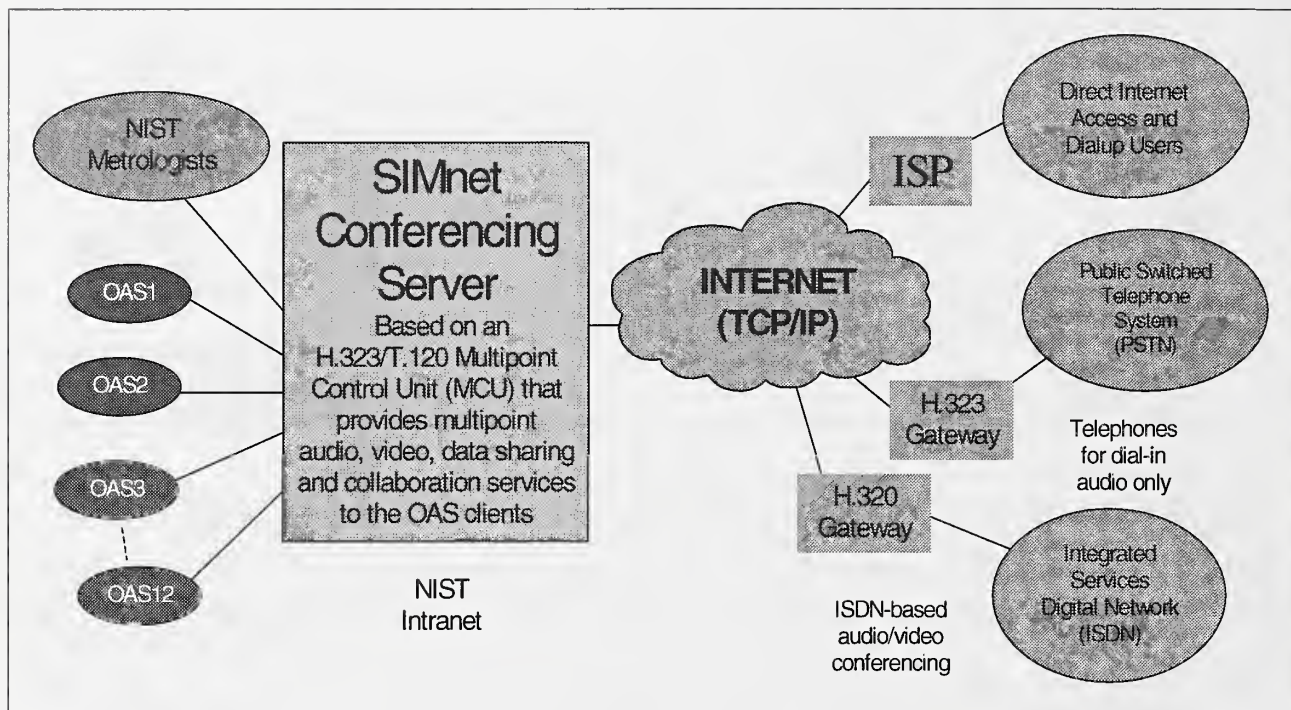


Figure 5: The SIMnet topology can support a variety of communication pathways.

By using telephony-based gateways in H.323 systems, all possible analog and digital telecommunication endpoints can be accommodated in the SIMnet system. Implementing telephony-based equipment in the current SIMnet pilot was outside the scope of the SIMnet mandate. However, those investigating the use of telephony-based services can obtain additional premises equipment and wiring required for these services from most Regional Bell Operating Companies (RBOCs) or Internet service providers (ISPs). For current SIMnet users, no special equipment beyond Internet connectivity and the off-the-shelf hardware and software as specified in this document is required. Additional equipment is needed only if users wish to support a telecommunications infrastructure not based on the Internet paradigm. Figure 5 illustrates how many different types of telecommunications access methods can be integrated into the current SIMnet design.

The ultimate goal of the communications infrastructure of SIMnet was to provide the capability to bridge various telecommunication mediums with an Internet-based solution for data networking. The current SIMnet design succeeds in providing an interoperable communication infrastructure by leveraging equipment based on internationally agreed upon multimedia and communication standards from the ITU, such as H.323 and H.320. The H.323 architecture is discussed in the next subsection.

2.3 H.323 Standards-based Architecture

The ITU H.323 Multimedia Conferencing architecture and protocols is the cornerstone of the SIMnet system. All H.323-based MCU and client hardware and software components used in the SIMnet system adhere to these standards. The H.323 series of standards define everything from the real-time protocols used over the Internet, to how audio and video data are encoded, transported and decoded across the Internet. The generic H.323 architecture is shown in Figure 6. The scope of the Recommendation H.323 is shown in the shaded region of the figure.

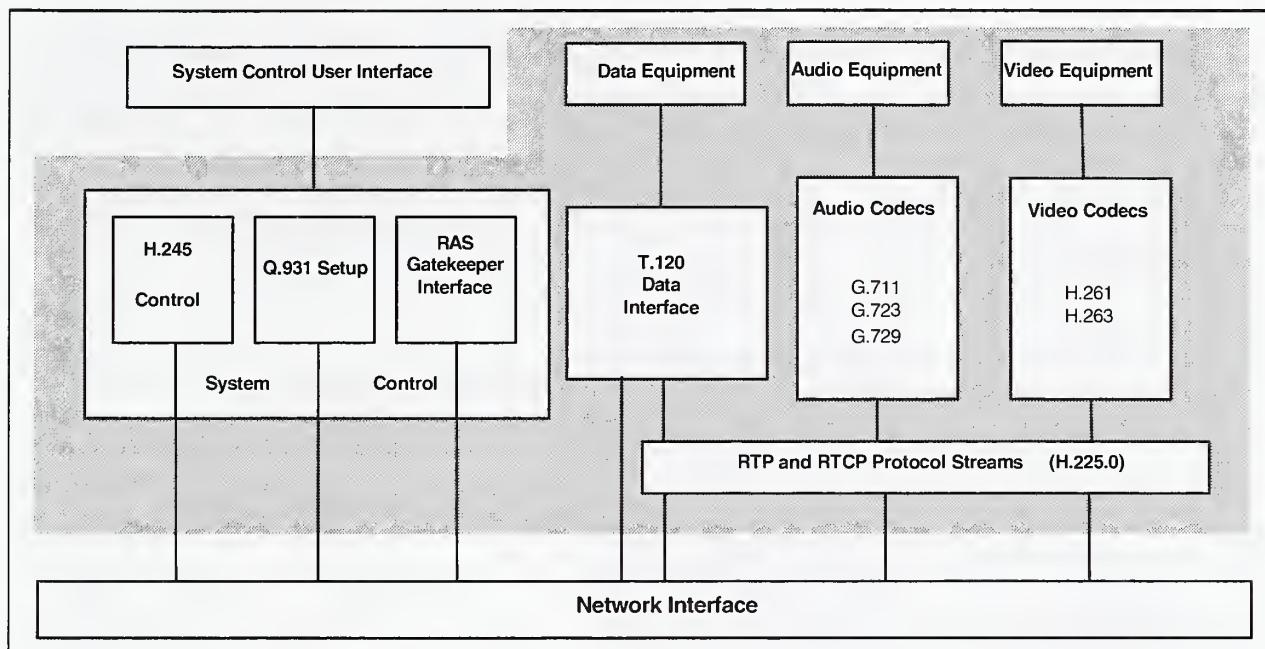


Figure 6: The ITU H.323 Standards-based Architecture.

Although consisting of many protocol layers as shown in Figure 6, the complete architecture is typically known under the one umbrella standard called H.323⁵. H.323 is an ITU standard that determines the specifications for terminals (PCs), equipment, and services for multimedia communication over networks, which do not provide a guaranteed quality of service (QoS) such as the Internet. H.323 network equipment typically transports real-time video, audio, and data, or any combination of these media. The audio and video standards are transported and controlled over a network using the Internet Engineering Task Force' (IETF) real-time protocol (RTP) and real-time control protocol (RTCP) initiative, respectively, as shown in the H.225.0 layer of Figure 6. T.120 data may optionally use the H.225.0 layer for transport or use the network layer directly. Additionally, protocols for call setup and signaling (Q.931), and data and audiovisual communications (G & H standard codecs (compression/decompression)) are also enveloped by the H.323 architecture.

Products using H.323 for audio and video enable users to interconnect and communicate with others over the Internet, just as you would make calls with different models of telephones over a PSTN. H.323 specifies how audio and video information should be formatted for transmission over the network. Standard audio and video codecs encode and decode compressed input/output from

⁵ An informative Frequently Asked Question or FAQ on H.323 is available at <http://www.intel.com/proshare/conferencing/h323/faq.htm>.

audio and video sources for communicating between nodes. Interoperability is the key to H.323 compatible products. Just as telecommunication standards allow telephones from different vendors to be used around the world, the H.323 standard enables the same level of interoperability for audio and video conferencing on the Internet.

H.323 specifies T.120 protocol services for data communications and conferencing within an H.323 session. T.120 is significant because the protocol defines and allows applications and data to become shareable over the Internet. The T.120 protocol allows the following scenario to occur: A user on Computer A starts an instance of Microsoft PowerPoint in an H.323 enabled conference. The user on Computer B sees the exact PowerPoint application as the user on Computer A. If the user on Computer A chooses to invoke the application using a collaborative mode, then the user on Computer B will also be able to interact with the PowerPoint application. More importantly, T.120 support allows data sharing to occur in conjunction with an H.323 audio and video-based conference, or in a standalone manner. This means that the audio and video portion of a videoconferencing application need not be running in order for the T.120-based data sharing capabilities to take place. This is acceptable in those situations where applications and data used during a scheduled SIMnet international comparison are required to be shared (i.e., an official SIMnet international comparison session is mandatory at a particular time), however, not enough bandwidth exists to support either real-time audio or video streams effectively.

The SIMnet system exploits the T.120 data sharing ability to deliver shareable NIST-developed metrology applications across the Internet for the purpose of validating electrical international comparisons. The next section discusses the collaborators that are currently using SIMnet in the electrical quantities measurement application domain.

2.4 SIMnet Collaborations

In support of the electrical measurement domain, engineers at the Electrical and Electronics Engineering Laboratory (EEEL) within NIST use development tools from National Instruments™ to create LabVIEW™ applications in a Microsoft Windows NT environment. The custom measurement and control applications developed at NIST serve as verification applications for the SIMnet metrologists to use when performing electrical measurement international comparisons. In Figure 7, a H.323 compatible client application (Microsoft NetMeeting™ 2.11) is used to share, display and control these applications during a SIMnet session with other conference participants. Participants in the SIMnet session all experience and visually document the international comparison in real-time.

Prior to any scheduled international comparison, a host country may download the appropriate password protected LabVIEW application from the NIST EEEL Web site⁶. For verification purposes, the host country then executes the application locally, while all other participants in the session view the shared application in real-time using their NetMeeting clients as it acquires measurements. An example of the NIST LabVIEW verification application is shown in the center of Figure 7, along with the real-time video images of the communicating participants as shown to the right in Figure 7.

For documentation purposes, SIMnet uses an “electronic notebook” paradigm to acquire images, measurements, files, and text for later storage into a database, notebook, or other electronic repository. This electronic notebook concept facilitates a more robust and complete method of

⁶ The NIST SIMnet Web Site is located at: <http://www.eeel.nist.gov/SIMNET-DMM>. This URL is case sensitive.

capturing important aspects during an international comparison session. Participants in the SIMnet system can use the documentation gathered during a SIMnet session as a training tool for other metrologists in their sectors.

Notice the dialogue in the Chat tool shown in Figure 7. The Chat feature can be used to help participants configure or tune session parameters (in this example, an audio configuration problem is being discussed) during a SIMnet session.

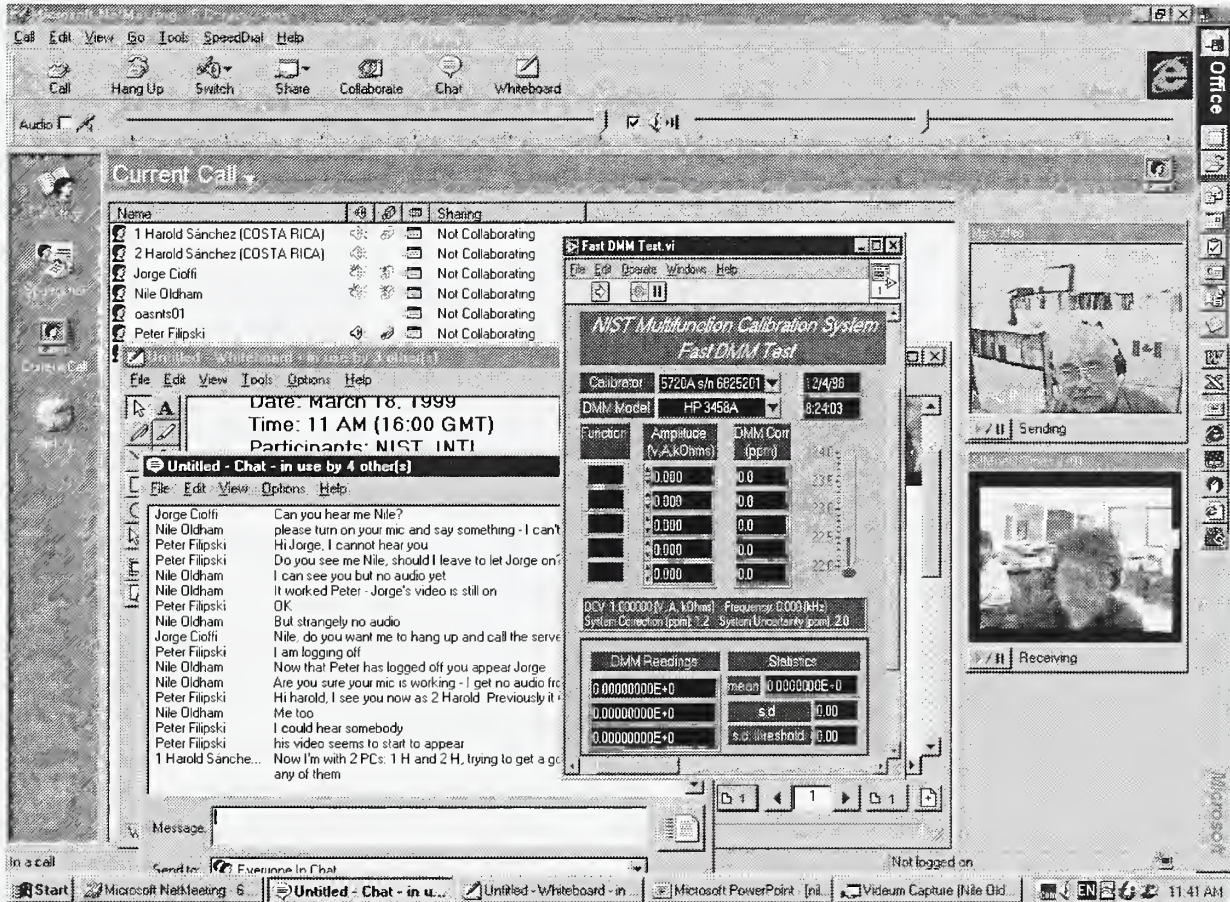


Figure 7: Participants in SIMnet using real-time audio, video, and application sharing.

The chat feature provides an alternative form of communication for anyone in the SIMnet session that might develop a problem or need to ask a question during the session. Used together these tools provide a valuable and exciting collaborative training aspect to the SIMnet system. The online training capabilities of this type of system are applicable to other application domains and have just begun to be fully exploited.

The next section details the requirements that NIST researchers gathered in order to support and specify the SIMnet Internet-based collaborative environment.

3 SIMnet Requirements

SIMnet grew out of early efforts by EEEL metrologists who were experimenting with videoconferencing tools to perform collaborative activities over the Internet. These early efforts predominantly used point-to-point NetMeeting connections over the Internet. The possibility of expanding this capability to multiple geographically disperse participants was an exciting concept. The proposed SIMnet system was envisioned as a real-time Internet-based videoconferencing system with collaborative features supportive of metrology applications. The next step was to define the feasibility and requirements of the proposed system.

To explore and develop such a system, EEEL Metrologists joined forces with Computer Scientists experienced in Internet-based solutions from NIST's Manufacturing Engineering Laboratory (MEL). MEL's mission supports advanced manufacturing research and standards development using information technology (IT). The umbrella project within MEL to support this mission is termed the National Advanced Manufacturing Testbed, or NAMT. NAMT provides an implementation framework for advanced manufacturing through its unique use of advanced information technology. There are a number of projects under the NAMT heading. There was expertise among NAMT project members in technologies requisite for designing a SIMnet system. The joining of NAMT and EEEL members on the SIMnet project resulted in a team of experts focusing on Internet technologies, building Internet solutions, metrology application expertise, and the vision to use these tools.

After several iterations of technical discussion with experts from EEEL and MEL including Metrologists, Computer Scientists, Network Engineers, and System Administrators, a great deal of information and ideas were logged concerning the kind of system that should be built and how it should be deployed. As the technical requirements for the SIMnet project solidified, it became apparent that the capability of providing a multi-user, Internet-based videoconferencing system with collaborative features would require the use of cutting edge technology. Until this time, such systems have been in the experimental realm and primarily limited to Intranet solutions. At about the same time, the significance of what the SIMnet capabilities could mean to the international metrology standards effort was becoming apparent. As a result, a large effort ensued to design, test, and deploy the SIMnet system. The SIMnet system definition process began by developing general system requirements for the design. The requirements of the SIMnet system definition are presented in Section 3.1. Additional requirements and refinements stemming from the Section 3.1 requirements review are discussed in Section 3.2.

3.1 System Requirements

In this section we detail the initial requirements from which the SIMnet system definition process began. We present the requirements as a list of items, with a motivation for the presence of each requirement.

1. **Support for Audio, Video, and Collaborative Features.** The use of audio, video, and application sharing in a real-time collaborative setting provides an expedient and natural way of supporting metrology activities. Each of these capabilities must be supported.

2. **Cost Effective and Timely Delivery.** Construction of the SIMnet system is to be cost effective, and a prototype system should be produced in a timely manner. All attempts should be made to obtain and use commercially available off-the-shelf (COTS) hardware and software for the SIMnet system in lieu of proprietary, custom, or in-house developed solutions. In general, COTS systems result in lower cost solutions with faster development times.
3. **Widely Available Hardware.** The hardware platform and required peripherals of the SIMnet system (particularly the systems required for participating sites in various countries) should be widely available and commercially supported.
4. **Software Requirements.** For the server portion of the system, an all software-based solution is preferred. An all software-based product is typically less expensive and easier to upgrade. In addition, it is imperative that the design supports a wide-range of metrology-based applications including in-house developed LabVIEW applications.
5. **Standards Usage.** A standards-based solution is preferred. The use of standards will ensure ease of connecting components of the SIMnet system, and is desirable for future growth/use capability.
6. **Internet-enabled.** An Intranet-based solution is not acceptable. Clearly, SIMnet must support and use some form of remote communications infrastructure to link the Americas. The Internet presents a flexible and cost effective means of providing this communication pathway. In addition, the SIMnet pilot program will identify mechanisms for the delivery of metrology and standards related services using the Internet.
7. **Ease of use.** The system should be easy to use at all levels of the operational system. This is deemed critical to a widespread acceptance of SIMnet. Both users and system/network administrators must be able to easily and effectively interact with the SIMnet environment in order to perform their duties. We expect a great technical diversity among users and administrators of the system between SIMnet participating sites.
8. **Geographically Disperse.** The participants of SIMnet will be geographically dispersed. Therefore, the deployment of the systems to the remote field sites will need to be made as straightforward and streamlined as possible. Logistic considerations are tremendous when considering a deployment of this magnitude, and therefore, the setup, installation, shipping, administration, and subsequent use of the remote systems must be simple. Remote control and administration capabilities will be required; these too must be streamlined and effective to support and solve technical problems that will undoubtedly arise.
9. **Support for Multiple Participants.** The SIMnet solution must provide simultaneous real-time audio, video, and shared applications to multiple sites and users. This requirement places a great deal of complexity on an Internet-based design and must be approached carefully.
10. **Security.** For the initial pilot system an acceptable level of system security shall be established. The ability to add security products for network and application security in the future will be required.

11. **Reliability.** Reliability is of great concern when deploying systems to remote areas. Maintenance, upgrades, and support of systems in the field can easily become a large portion of a project's budget. The hardware and software components procured for the SIMnet system should be reliable and relatively maintenance free. Also, proven software products should be used when possible to minimize software problems after deployment.
12. **Internet Bandwidth.** The SIMnet solution should allow for a wide-range of available bandwidth speeds. In some regions of SIM, only low-bandwidth connections are available to connect to the Internet. The SIMnet sites located in such regions should be considered in the design.
13. **Expansion and Growth.** The SIMnet system should allow for growth both in use and as new software and hardware capabilities become available. A favorable acceptance of the SIMnet solution will expand the base of participants teaming to collaborate on projects. The system should scale to handle the expected growth in teaming and collaboration.
14. **Maintainability.** The ease of distributing software upgrades, system patches and hardware upgrades/replacements to participating sites will be considered and made as straightforward as possible.
15. **Support.** A SIMnet support plan will be designed to address training, technical support, and gathering feedback from users. Support in the form of service contracts for the hardware and software of SIMnet must be capable of covering all of the Americas.

In the next section, we elaborate on a few key decisions, which resulted in additional requirements that further influenced the final outcome of the design.

3.2 Additional Requirements

Based on initial research for the SIMnet system, a few refinements to the original requirements emerged. The efforts to address the issues in Section 3.1 led to a more focused design effort and paid off in terms of constraining our solution base. Each of the “add-on” requirements and refinements are presented here and include (1) why an audio and video broadcast/multicast solution was ruled out, (2) issues which led to favoring Microsoft's NetMeeting as our H.323 client, and (3) a requirement that the SIMnet design provide multipoint control unit capabilities at the server.

3.2.1 Broadcast and Multicast Issues

Initially, the SIMnet system design research began by investigating the possibility of using a broadcast or a multicast audio and video streaming solution for SIMnet. In this subsection we discuss streaming media using broadcast and multicast technology and why this was not a feasible solution for SIMnet.

Multicast and broadcast streaming of video and audio over the Internet is typically used in theater settings or to playback pre-recorded media for viewing at a later date, such as a seminar, sports event, or speech. This technology is currently in use on the Internet to stream audio and video-based events such as earnings reports from Wall Street or CNN broadcast news and cable content.

Streaming media is typically sent out over the Internet in either broadcast or multicast mode with no inherent two-way feedback mechanisms. In broadcast mode, there is no ability to stream in real-time due to the fact that the capture, digitization, compression, and unicast transport requirements are highly compute-intensive operations. Even the best streaming servers cannot broadcast data in real-time. Providing *near* real-time capabilities using broadcast technology is possible. However, in this case dedicated high-end servers would be required at each participating client site to support a one-way broadcast of video and audio streams. This adds considerably to the software and hardware required and to the complexity of the system. Several products are available for the audio and video broadcast streaming and Webcasting marketplace including: Microsoft NetShow™ Theater Server, RealNetworks™ RealServer G2, and Galacticomm™ WebCast Pro Server.

The two reasons broadcast-based streaming media was ruled out as a SIMnet solution are: (1) it lacks real-time capabilities, and (2) it lacks support for interactivity. Thus the technology did not inherently satisfy two of the major requirements for the SIMnet system. We then began to look at using multicast mode for delivering streaming audio and video media. The use of multicast audio and video would be appropriate in cases where the passive viewing of a SIMnet session was acceptable. An H.323 client could simply connect to a multicast endpoint in a conference to passively view an international comparison. Multicast streaming could also be used as a means of delivering a Webcast⁷ approach, which would supply one-way audio and video to any standard Web browser during international comparisons. The use of passive multicasting or WebCasting would also be acceptable for supporting more participants in the conference without requiring additional software licenses for each server.

An optional component in the H.323 recommendation addresses using multicast in support of H.323 conferencing. Unfortunately, at the time of the SIMnet design and implementation, there were no H.323 compatible products that implemented the optional H.323 multicast capability. If in the future, there is a requirement for the SIMnet system to provide multicast capabilities, we expect that implementations will be in place to support it. As of this writing, there was only one H.323 product that supports conferencing using the optional H.323 multicast capability. This product is called MeetingPoint™ Conferencing Server from White Pine Software. Unfortunately, in order to fully utilize H.323-based multicast Internet connections, all TCP/IP protocol stacks, computer operating systems, network interface cards, client endpoints, routers, switches, and MCU's must all comply with and support the multicast standards. As of this writing, no guarantee can be made that all Internet routes used by SIMnet clients can support multicasting technology. This is why the unicast point-to-point connection method for connecting to MCU's is used in the SIMnet system design. Multicasting will be an important technology for SIMnet once the technology has been fully integrated with all required hardware and software on the Internet.

3.2.2 Experience with Microsoft NetMeeting

The MCU provides the server capability to support H.323 compliant clients. A great deal of time was spent experimenting with H.323 clients that could be used in SIMnet. The Microsoft NetMeeting client was favored early on based on user experience, cost, ease of use, and availability issues. NetMeeting was already being used for experimental point-to-point metrology

⁷ Webcasting uses "server push" technology to broadcast or multicast audio and video data to the Web. Internet users then simply point their browsers to the location of the Webcast server; the data is then delivered to the user through the browser. Webcasting does not provide real-time imaging or two-way interactivity. It is a popular audio/video distribution technique used on the Internet to support traffic, weather, and other data retrieval where real-time requirements are not exceedingly stringent.

collaborations taking place between NIST and various other SIM members (in particular Canada and Mexico). The feedback on the product was favorable from the users involved in these early collaborations. The NetMeeting product comes bundled with Internet Explorer and is therefore readily and freely available. Many users already had experience with NetMeeting and were familiar with the user interface.

As researchers began to experiment more and more with NetMeeting, it became clear that the SIMnet design could substantially benefit from leveraging all of the capabilities of the NetMeeting client. That is, not only would the real-time audio and video be invaluable during SIMnet sessions, but the ability to document the experience with a whiteboard was exciting as well. To add to the SIMnet experience, an online chat was available as well as inherent file transfer capabilities.

The NetMeeting product fully implements the ITU H.323 protocol stack. Microsoft is a member of the ITU H.323 committee on multimedia conferencing standards. This was an important consideration in light of the decision to focus on the use of the MCU and its requirement for a client to be H.323 compliant. For all of these reasons NetMeeting was the favored H.323 client application as we entered the SIMnet design stage.

3.2.3 Multipoint Control Unit (MCU) Capabilities

Further research into the capabilities of the H.323 protocol provided clues as to how to provide the desired NetMeeting-like point-to-point capabilities to multiple member countries simultaneously and in real-time. A major part of the H.323 standard discusses a concept called a Multipoint Control Unit, or MCU. From the ITU H.323 Version 3 Draft, MCU is defined:

multipoint control unit: *The Multipoint Control Unit (MCU) is an endpoint on the network, which provides the capability for three or more terminals and Gateways to participate in a multipoint conference. It may also connect two terminals in a point-to-point conference, which may later develop into a multipoint conference. The MCU generally operates in the fashion of an H.231 MCU; however, an audio processor is not mandatory. The MCU consists of two parts: a mandatory Multipoint Controller (MC) and optional Multipoint Processors (MP). In the simplest case, an MCU may consist only of an MC with no MPs. An MCU may also be brought into a conference by the Gatekeeper without being explicitly called by one of the endpoints.*

In implementation terms, the MCU (also known as a multipoint conferencing server, or MCS) is realized in software or hardware as a server to support multiple connections from H.323 compliant clients. In effect, a MCU-based system provides the multipoint capability that would allow a point-to-point NetMeeting connection between two people to become a multi-party meeting. The MCU not only provides an environment that supports multi-way connections, but it also fosters the ability to support all capabilities of NetMeeting simultaneously and in real-time. The MCU server accomplishes this by replicating all H.323 data streams to each H.323 compliant client in the conference via Internet-based TCP/IP unicast connections.

Researchers quickly began to study all products that implemented an H.323 compliant MCU. At the time SIMnet was being conceptualized, three vendors had products that would meet most of the specifications for SIMnet. The small number of products was due to the relative immaturity of the H.323 standards (the H.323 standards were recently ratified and approved)⁸ and a general perception that the Internet is not a suitable platform for real-time communications because it lacks a guaranteed quality of service. Based on this information we entered the design stage focused on using a MCU capability as part of the SIMnet solution.

⁸ The ITU-T H.323 Recommendation Version 1 was ratified in May 1996. Version 2 was ratified in January of 1998, and version 3 is still in Draft form as of this writing.

4 SIMnet Design

The SIMnet system would be based on an interactive two-way audio and video conferencing paradigm for the Internet. In addition to supporting audio and video conferencing on the Internet, NIST researchers were invariably looking for a standards-based design that provided collaborative features as well. A scalable design was also mandatory for future growth, but was not a mitigating factor in the initial prototype design. In fact, we knew that the OAS consisted of 34 member countries of which only 11 of them would be participating in this trial. Therefore, initially, it was not expected that the SIMnet prototype would be required to handle more than 12 users concurrently (the 11 member countries and NIST). Therefore, even though scalability was important for the long-term, a standards-based off-the-shelf solution was the highest near-term priority.

The approach we used to design the SIMnet system was very specific - the design was based entirely on the requirements that were defined in Section 3.1 and 3.2. In addition, because the H.323 standards address the problem of providing a multi-way conference on the Internet using a standards-based framework, we only tested products based on H.323 for compliance with our requirements. Ultimately, the product that best fit our requirements for SIMnet was selected. Upon selection, the hardware and software for the product would be sized and procured. A pilot system would then be setup and evaluated for incorporating feedback into the iterative design process. This section begins by describing the design process in greater detail. Subsequent sections cover sizing, procuring, and setting up the pilot system for the initial SIMnet trials.

4.1 *Client-Server Design*

The H.323 standards requirements for the SIMnet system placed certain constraints on the design. In order to satisfy the requirements for an H.323 compatible system, an MCU was needed to provide the multi-party interactive capabilities in the SIMnet system. All MCU implementations are based on either a client-server model, or a hybrid of the client-server environment. In any event, it was clear that a server based on an H.323 compatible MCU would be required to allow clients to “call” into the server as shown in Figure 8. By definition, the MCU-based server then redirects the real-time audio, video, and data streams of information to each client in the field simultaneously.

The SIMnet server machine supporting the MCU would physically be located at the NIST facility, satisfying the ease of administration requirement. The client systems would be located remotely in the field and represent each member nation of the SIM effort. The centralized client-server design reduces the amount of maintenance and administration in the field by consolidating the complex functional portions of the system to just one location. The single serviceable item in the field includes off-the-shelf desktop computers running an H.323 client.

Contrast this approach with the broadcast audio/video solution that requires a server-based capability at every remote client site. The broadcast configuration would require inordinate amounts of hardware, software, and administration just to support the audio and video portion of the requirements.

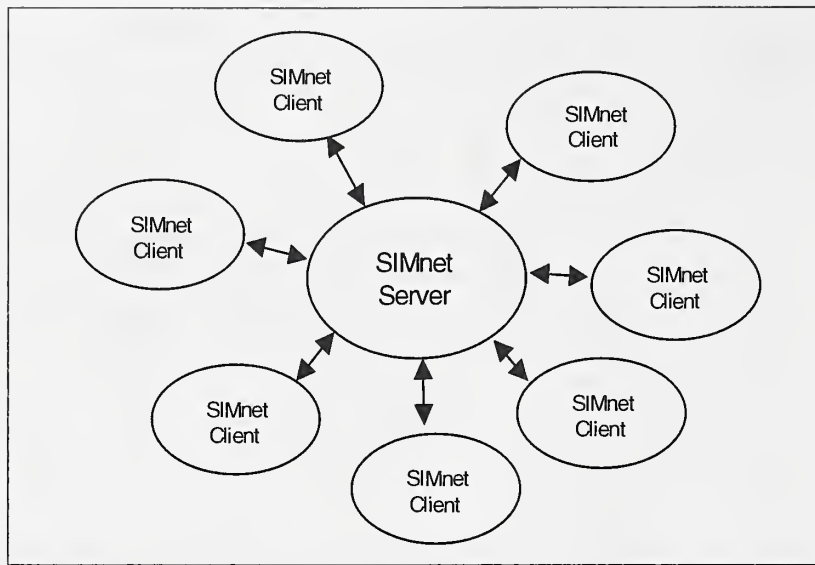


Figure 8: The SIMnet architecture uses a client-server design.

A search began for all products that supported Internet-based H.323 standards for audio and video multimedia conferencing. Our research quickly found several products that supported the H.323 standards. However, there were certain features based on the requirements that we specifically were looking for; namely, a server design based on software, interoperability with NetMeeting, and a system that runs on Windows NT. The products that met our requirements at the time of the SIMnet design included PictureTel's 330 NetConference Multipoint Server⁹, RadVision's OnLAN MCU 323¹⁰, and DataBeam neT.120 Conferencing Server¹¹.

Of the three contenders, the PictureTel 330 MCU was chosen for a variety of reasons including: (1) it provides a software-only solution, (2) it executes on Windows NT Server, (3) it provides support for the most number of users, and (4) it is highly interoperable with Microsoft NetMeeting. The RadVision OnLAN product was very similar to the PictureTel product in scope except that the PictureTel 330 provides a software-based solution for Windows NT, whereas the OnLAN product uses a dedicated and proprietary Windows NT hardware package. Upgrading the OnLAN product for more users or newer versions of the firmware would require additional hardware resources and be more costly, respectively.

The DataBeam neT.120 product was not chosen because it only provides the T.120 portion of the H.323 protocol stack. The T.120 protocol recall provides only the data and application sharing capabilities. This means, if we were to use the DataBeam neT.120 product, we would still require add-on software or hardware at the server to provide the real-time audio and video conferencing capability. We instead were looking for an all-in-one H.323 compliant product. Therefore, based on upgrade and interoperability requirements, we chose the PictureTel 330 product. Figure 9 illustrates this decision path that defines the requirements needed to start the product selection phase.

As Figure 9 suggests, after a product has been chosen based on the requirements, the specific hardware supporting the product selection must be defined for the server. The remaining parts of

⁹ PictureTel's 330 NetConference Multipoint Server information is available at <http://www.pictel.com/ptel330/jump.htm>.

¹⁰ RadVision's OnLAN MCU 323 information is available at <http://www.radvision.com/products/mcu.html>.

¹¹ DataBeam's neT.120 Conferencing Server information is available at <http://www.databeam.com/net120/index.html>.

this section discuss the design of the SIMnet server hardware and software with respect to the requirements that the PictureTel 330 software places on the design. The section then concludes with the basic design of the software and hardware components used to satisfy the client requirements.

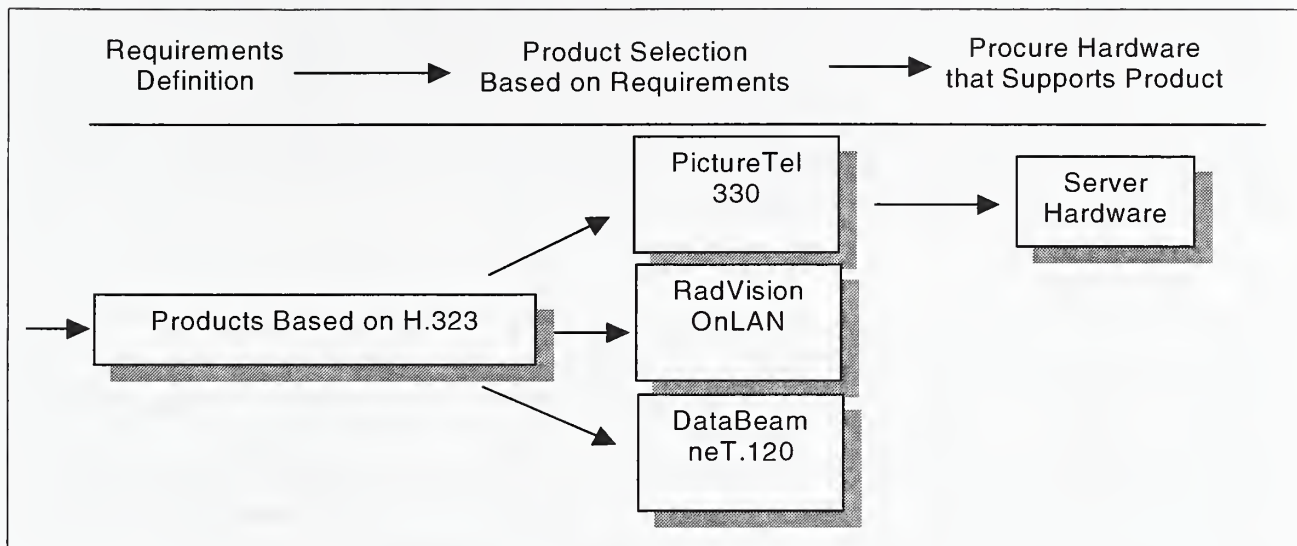


Figure 9: The SIMnet server requirements definition process.

4.2 Design Issues

The client-server design of SIMnet provided many advantages as well as some drawbacks. The advantages were significant and include reducing the amount of personnel required to support systems in the field. This number becomes almost non-existent due to the simplicity of the desktop computer systems defined for the client sites. Desktop PCs used in the field to “call” the conference can be very modest systems. All of the complexity of the SIMnet system is built into the centralized server at the NIST site. This allowed the use of off-the-shelf software (i.e., Microsoft NetMeeting) on the client systems to “call” into the conference server.

Microsoft NetMeeting as well as the conference server (PictureTel 330) all use internationally agreed upon standards for multimedia communication. In addition to NetMeeting, any H.323 based client can be used to “call” into the conference, including PictureTel LiveLAN, Intel ProShare/VideoPhone, White Pine’s CUSeeMe, as well as other emerging H.323 client applications. Therefore, the use of the PictureTel 330 server in no way limits the field of possible products that can interoperate with this system.

Mobile users can participate in conferences using low-bandwidth modems, an ISP, satellite, or other means of connecting to the Internet. Firewalls can be programmed and configured to deal with the standardized TCP/IP ports that the audio and video and data sharing protocols use. Systems based on the client-server paradigm scale well to the more limited Internet capabilities that exist in the less “wired” areas of the globe. NetMeeting-based videoconferencing client systems are already familiar to engineers and metrologists who are currently using it on a point-to-point basis.

Disadvantages of the current client-server design include: (1) Security during collaboration activities is a concern. No security problems exist however during simple sharing of applications.

“Roberts’ rules” and agreed upon client responsibilities are needed prior to conferencing (i.e., non-collaborators should only observe the audio and video). Ongoing research and product evaluation of both hardware and software solutions to H.323 multipoint conferencing must continue to fully gauge the impact and capabilities. (2) There is no support at this time for inherent Internet broadcast/multicast, should this become a mandatory requirement at a later time. However, this solution does not preclude using H.323 techniques to add broadcast or multicast capabilities when ratified. (3) There are very high-costs associated with providing a per-client machine broadcast system. Most sites cannot support broadcast requirements due to limited Internet communication speed. Current technology for adding broadcast capability in addition to collaborative features is “bleeding edge” at best and highly proprietary.

4.3 SIMnet Server

The basic design of the SIMnet server was driven directly from the hardware and software requirements placed on it by the PictureTel 330 guidelines. The PictureTel 330 software requires Microsoft Windows NT Server 4.0 to be loaded and running on the server in order to operate. Therefore, additional software design requirements are based on providing for the Windows NT Server operating system as well. On the hardware side, PictureTel recommends a specific class of high-end Pentium server-class machine to execute efficiently. The following subsections will detail the basic software and hardware design requirements that have been defined in order to describe the SIMnet system using the PictureTel environment.

4.3.1 SIMnet Server Software

The SIMnet server requires two important pieces of software including the Microsoft Windows NT Server 4.0 operating system and the PictureTel 330 NetConference server software. In support of these two server components, the server requires several software entities to be installed before the system can be used effectively as a SIMnet server. In addition to the mandatory components found on the server, several miscellaneous software items are convenient to install, including Web server and system backup software. These items are useful for administrative activities on the server and are not required to support the operational infrastructure of SIMnet. The next subsections will further define the software design requirements for the SIMnet server in terms of the PictureTel 330 server, Microsoft Windows NT Server, and other miscellaneous software.

4.3.1.1 PictureTel 330™ NetConference™ Multipoint Conferencing Software

At the heart of the SIMnet system is a videoconferencing server that provides easy and flexible ways to schedule, host, and participate in Internet-based electronic meetings. The PictureTel 330 NetConference software provides this capability by fully implementing the ITU H.323 MCU or multipoint control unit specification. The PictureTel 330 software was designed for Windows NT and executes as a service on a dedicated Windows NT server machine. The PictureTel 330 software provides an environment in software that supports multi-party audio and video conferencing over the Internet. In addition to the audio and video capabilities, the PictureTel 330 software provides collaborative data and application sharing features via its implementation of the H.323-based T.120 protocol.

The NetConference server software provides an environment that is similar to a traditional meeting in a conference room. People meet in a room (albeit virtual) that has a certain amount of seating available. The administrator can reserve rooms in advance so that enough seating will be available

for the meeting. After a meeting is underway, the room can be locked. For ad hoc meetings, a public virtual meeting room can be used without reservations. The virtual rooms have their own names assigned to them and they can be public or private as defined by an administrator.

The PictureTel 330 server manages the audio, video, and data sharing capabilities for each meeting. The current version of NetConference (Version 2.0.1) is in beta testing at NIST and can support up to 40 clients. This means up to 40 people can connect into one large meeting or into several smaller meeting rooms. Anyone on the Internet can use NetConference as long as they have a H.323 compatible client desktop videoconferencing system such as PictureTel LiveLAN, Microsoft NetMeeting, or Intel ProShare for example. These desktop systems not unlike the SIMnet client systems used in the field are called H.323 clients because they implement the H.323 technical standards. By implementing these standards, clients and the server provide standardized:

1. Audio
2. Video
3. File transfer
4. Application sharing
5. Real-time collaboration
6. Text-based Chat and a graphical Whiteboard

The PictureTel 330 software provides these capabilities by executing as a multi-threaded Windows NT application. In order to execute the PictureTel 330 software, a Windows NT Server 4.0 environment is required. The next subsection describes this environment with respect to fulfilling the PictureTel 330 application execution requirements.

4.3.1.2 Windows NT Server 4.0

Use of the Microsoft Windows NT Server 4.0 operating system in this case was mandated by the requirements placed on the design by the PictureTel 330 NetConference Multipoint Server software. However, we were looking for a Windows NT solution as we have a large administratively qualified support base internally at NIST.

In order to take full advantage of all features in the PictureTel 330 installation, one should take note of the following prior to the PictureTel 330 installation process. Please note that the suggestions stated below are based on the installation requirements of the PictureTel 330 version 1.01 software.

- **NTFS Support.** Windows NT Server 4.0 supports both the standard disk operating system (DOS) file allocation table (FAT) file system and the NT File System (NTFS). To take full advantage of Windows NT security and access control for data files, as well as to maximize file system performance, Microsoft recommends that Windows NT Server be configured to use NTFS. Moreover, the PictureTel 330 software requires the use of NTFS for its security features to work correctly and to achieve optimal performance during file system intensive activities.
- **TCP/IP Networking.** The SIMnet server environment requires TCP/IP for correct functioning. TCP/IP is also the defacto protocol in use on the Internet. It can be disadvantageous to install other network protocols along with TCP/IP, such as Novell's IPX/SPX or NetBEUI. Use of other protocols on the server will only serve to slow the overall system processing of the server down by adding time consuming protocol activity. In addition, the TCP/IP network protocol

must be installed for Internet Information Server (IIS, is Microsoft's Web Server technology) to operate correctly. IIS can be used to remotely administer the PictureTel 330 server and will be discussed in the next section.

- **SNMP Support.** Install the simple network management protocol (SNMP) support if there is a need to support large clusters of PictureTel 330 servers or if remote network management capabilities are required. Use of the latest SNMP version that uses the management information base version 2 (MIB-2) will provide enhanced features for easier configuration and monitoring of network resources.
- **ActiveMovie™ Support.** Microsoft ActiveMovie, the runtime version 1.0 (or higher) must be installed on the Windows NT Server prior to installation of the PictureTel 330 server software. The ActiveMovie runtime allows the PictureTel 330 software access to ActiveMovie services, which provide playback of various multimedia streams from the Internet. Specifically, this allows playback of video and audio content, compressed in various formats including: motion pictures experts group (MPEG), Apple Computer's QuickTime, or Microsoft's native audio video interleave (AVI) file format. The ActiveMovie runtime is available from the ActiveMovie software development kit (SDK) from Microsoft. The recommended location to obtain the ActiveMovie runtime is directly from the PictureTel 330 installation Compact Disk-Read Only Memory (CD-ROM).
- **DAO Support.** Microsoft Data Access Object (DAO) drivers are required for the PictureTel 330 software to maintain databases and logging information for later debugging and security monitoring. Again, DAO support can be found on the Microsoft Web Site or from the PictureTel 330 installation CD-ROM disk.

4.3.1.3 Internet Information Server (IIS)

A Web Server can support convenient software tools for effectively managing the remote administration and scheduling of conferences in the PictureTel 330 environment. On a Windows NT platform, the Microsoft Internet Information Server (IIS) 4.0 is the recommended Web Server software for use with the PictureTel 330 server. IIS 4.0 is typically installed as part of the Windows NT BackOffice Server installation process or by explicitly using the NT options pack add-on package available from Microsoft. A minimum installation of IIS should include the World Wide Web Services, or the hypertext transfer protocol (HTTP) server, and the Internet Service Manager, a tool for configuring and administering IIS. Newer versions of the Internet Service Manager can be found using the Microsoft Management Console (MMC) in IIS 4.0.

The IIS 4.0 Web Server is convenient to have on the NT Server platform because it provides a means to access the remote administration, maintenance, and scheduling tools of the PictureTel 330 server via the Web. This ability to administer the PictureTel 330 server via the Web is called the PictureTel Web Center and is based on HTML pages, and Java applets. This means, the administrator can bring up a Web browser such as Netscape™ Navigator™ or Microsoft Internet Explorer™ and administer the server (with a correct password), host meetings, or schedule rooms for meetings. The home page of the PictureTel NetConference WebCenter is shown in Figure 10.



Figure 10: Web Center is PictureTel's Web-based remote administration facility.

Administrators of the Windows NT-based PictureTel 330 server also have the option not to install the IIS 4.0 Web Server software for security concerns or because of other installation constraints on the system.

Providing a Web-based remote access method is extremely convenient because it eliminates any excess software from being loaded on a workstation in order to perform SIMnet administration. In addition, the administrator can remotely administer the PictureTel 330 server from virtually any desktop or laptop that has a Java compliant Web browser executing on it. However, if the Web services are not installed on the server, then this method of remotely accessing the server cannot be done. In this case, a dedicated client application must be loaded on each workstation or laptop that expects to have remote administrator privileges on the PictureTel 330 server.

4.3.1.4 Network Administration Console

In addition to using the Web-based Java tools provided through the NetConference Web Center, PictureTel provides a dedicated client software tool to remotely administer the PictureTel 330 server in the event that the Web Center was not installed or an alternative means of access is required. The PictureTel 330 dedicated client application is called the Network Administration Console or NAC shown in Figure 11.

The major difference between this tool and using the Web Center is that an administrator must install this tool on each client workstation or laptop in order to access the PictureTel 330 server from over the network. There are some minor differences between the capabilities of the NAC and

the Web Center based administration tools. Both tools however provide the basic administration capabilities needed to control the conferencing server.

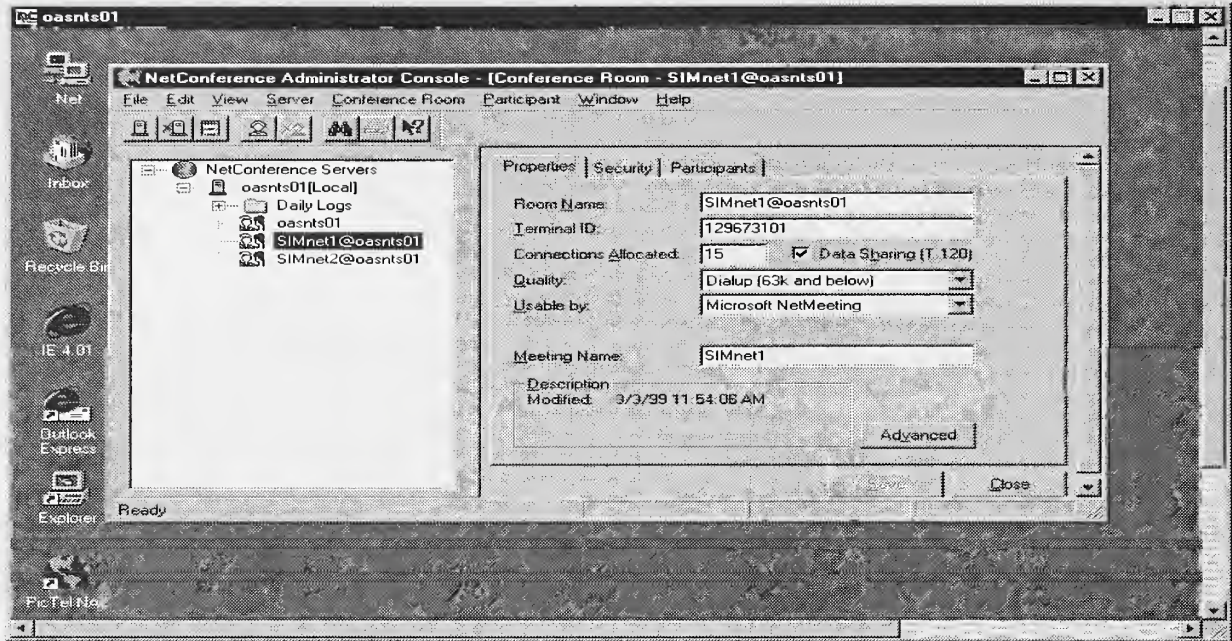


Figure 11: The user interface of the PictureTel 330 NetConference Administration Console.

4.3.1.5 NetConference Scheduler

When supporting many PictureTel servers for different groups or divisions, a centralized and effective means of scheduling rooms and marking them for specific security attributes is needed. PictureTel provides a Web-based software package to help administrators schedule availability of rooms. In addition, administrators must be able to mark rooms with certain security attributes using public, private, or reserved room criteria. Although not currently used in the SIMnet design, this capability will be useful later as more complex schedules emerge or as the need for increased room size partitioning becomes mandatory.

The PictureTel Scheduler™ provides the capability to automatically notify participants via email about upcoming meetings. The Scheduler software controls all room and security configurations in order to enable all approved personnel to dial-in and connect to the meeting room. The Scheduler Web-based access and control program will be implemented in the final rollout of the SIMnet trials. As this adds more to the administrative overhead of maintaining a system like SIMnet, a determination of usage feasibility must be made for smaller organizations with fewer resources, simpler room configurations, or increased security requirements.

4.3.2 SIMnet Server Hardware

The hardware requirements for the SIMnet server includes those components normally found with a high-end server-class machine. These items will be discussed individually and with respect to the current NIST server hardware already deployed. Notes about additional capacities whether for CPU, memory, or the new 40-port version of the PictureTel 330 server will be made available from the SIMnet Web site.

4.3.2.1 Central Processing Unit (CPU)

The amount of CPU power required for a site to function as a SIMnet server will be based on both the anticipated amount of traffic and the quantity of dynamic connections to the site. For example, the PictureTel 330 server software is licensed by the number of ports or users that can simultaneously connect with a particular conference room on the server. The number of conference rooms is based on the total number of allocated ports for each room. As of this writing, the PictureTel 330 conferencing server software is available in 8 and 24-port versions. The NIST SIMnet server is currently using the 24-port version 1.0.1 release.

We have been experimenting with a beta version (version 2.0.1) at NIST that supports 40 ports or users per server and requires a great deal more CPU power to handle 40 concurrent audio, video, and data sharing streams. The beta version was just upgraded to product release (version 2.1) status and has been in use at NIST on our testbed server. The production SIMnet server has not been upgraded and continues to use the 24-port 1.0.1 version. In order to support the 24-port version 1.0.1 PictureTel 330 server, the following CPU requirements must be met: at a minimum, the SIMnet server requires dual (2) Intel Pentium II 266 MHz processors. The 40-port version requires even more stringent CPU specifications. The 40-port version 2.1 requires at a minimum quad (4) Intel Pentium II 266 MHz processors.

4.3.2.2 Memory

As with the CPU requirements, determining the amount of memory for a server is largely a question of how much traffic is expected and how compute-intensive the site will be. A simplistic but true maxim is the more memory, the better. It is equally true, although perhaps less obvious, that the available memory must be appropriately partitioned among processes. This means balancing the memory requirements of the SIMnet server with Windows NT as efficiently as possible helps tremendously. An important aspect of tuning the SIMnet system is to alter the background performance of Windows NT Server. Configure the Windows NT Server so all threads in the system are treated equally. (Do this by editing the System properties. On the performance tab, move the slider to select a Boost of None.) This new setting will provide fair access to computational resources to all competing processes on the server.

The PictureTel 330 server software suggests a minimal server configuration running Windows NT Server and IIS 4.0. The PictureTel 330 24-port version on a Windows NT Server requires a minimum of 128 MB of Random Access Memory (RAM). However, a server will utilize additional memory if provided. Adequate memory is one of the most important determinants of overall efficiency in the SIMnet system.

4.3.2.3 Disk Subsystem

Proper configuration of the disk subsystem is critical to ensure adequate SIMnet site performance. There are two aspects to disk subsystem configuration: choosing the correct disk controller for the site, and guaranteeing sufficiently high throughput based on the server application domain.

Windows NT implements the most commonly used redundant arrays of inexpensive disks (RAID) levels in software to provide fault-tolerant disk performance. This provides all of the data security and much of the performance improvement for a fraction of the cost of specialized hardware RAID implementations, thus minimizing the likelihood of data loss. If a disk hardware failure does occur, however, hardware RAID implementations typically offer hot swappable drives, background

rebuild, and other functionality specifically designed to minimize server downtime that Windows NT-based software RAID solutions do not provide.

RAID systems are typically given numeric values to designate completeness of implementation. Lower RAID values equate to less controller overhead resulting in higher performance in the underlying disk subsystem because the controller does not have to implement replication, striping, or perform additional parity checking activities. However, those activities provide the fault tolerant support that some may require in their systems. Because, the SIMnet server does not service many I/O requests, the RAID system should be designed to be more fault-tolerant than efficient. Therefore, for the SIMnet server, we recommend a minimum of RAID 5 for maximum redundant protection with only a slight performance hit from the RAID 5 controller overhead.

If a SIMnet site is expected to have a large volume of traffic, or contains complex content or content consisting of a number of large files, it is well worth investing in the fastest hard drive and drive controller. The small computer systems interface (SCSI) products based on SCSI-2 or SCSI-3 drives paired with 32-bit SCSI controllers will provide reasonable performance. You can gain additional performance by acquiring a high-speed SCSI host adapter that performs asynchronous I/O, permitting multiple disk accesses to occur simultaneously. One note of caution however, it is not recommended to use the SIMnet server machine for other than supporting the PictureTel 330 software. The PictureTel 330 process is a highly compute-intensive one. Therefore, additional applications on the system may interfere with the SIMnet server's ability to service client connections efficiently. Under no circumstances should audio or video hardware (i.e., the hardware used in the client systems) be used on the SIMnet server, as this will interfere with the PictureTel 330 multimedia delivery and application activities.

The SIMnet server is typically classified as a network and CPU bound machine as opposed to being overly input/output (I/O) bound. This means that for the PictureTel 330 application on the server to perform at its best, the server must be maximized for CPU speed and to respond quickly to the network. Therefore, the server must be configured with hardware and software mechanisms that boost the overall CPU performance and the throughput of the underlying networking subsystem.

4.3.2.4 Network Subsystem

The network interface card (NIC) used in the SIMnet server should provide the highest possible throughput available as the networking subsystem is critical to successful overall server performance. In addition to using a high performance network card, the type of backbone network that the server attaches to is also critical. The network the server attaches to must provide the highest available bandwidth to support multiple unicast TCP/IP connections. This is critical because if the server cannot allocate connections or transport data to all connected clients in time, the system will degrade and result in a poor quality meeting.

Clearly, most of the SIMnet clients connect to the server using Internet connections that are considerably less capable than the server's local area network speed. However, the server must be able to locally support transmitting multiple unicast TCP/IP connections during a SIMnet meeting. Supporting multiple connections requires a great deal of bandwidth availability on the local backbone. If the local backbone cannot support the server's networking requirements, then the meeting will not be able to proceed effectively. The NIST SIMnet server is located on (at a minimum) a switched 10 Mbps dedicated Ethernet-based networking infrastructure.

The other aspect of providing an optimal networking infrastructure for the server has to do with maintaining efficient or limited routing. Routing on a network is needed when the backbone is subdivided into many parts called *subnets*. Subnets help to manage the network infrastructure by partitioning it into smaller units. Partitioning increases overall performance of the network by reducing the total amount of traffic on the backbone. The bad news however is that routing over many subnets incurs a great deal of overhead resulting in lower overall end-to-end network performance.

In order to function properly, routers must examine each packet that traverses the network to determine where it should go next. If there are significant numbers of routers on the SIMnet backbone, then the overall performance of the network will suffer. Therefore, when deciding on a location on the network for the SIMnet server, care must be taken to place the server physically on a segment of the network that contains as few routers as possible before the physical Internet connection or point-of-presence network access point.

4.4 SIMnet Clients

The SIMnet client machines that will be located in the field will be equipped with a very basic complement of software tools. Ultimately, our goal with designing the SIMnet client workstations was to keep the software and hardware configurations as simple and standardized as possible to eliminate unnecessary service, support, and maintenance costs. Therefore, we designed the client workstations to have a minimally configured and standardized suite of software without expensive, custom, or proprietary solutions. Trying to maintain sophisticated and complex machines remotely would be cost prohibitive.

The SIMnet clients are general-purpose, off-the-shelf personal computers (PC). The client systems were specifically designed to allow metrologists to easily and effectively attach to the Internet and participate in a collaborative SIMnet system. The key SIMnet client software and hardware design issues can be broken down into two areas: those that address generic desktop functionality and those supporting the SIMnet specific application domain. In order to support this design, several key software and hardware components were added to the off-the-shelf desktop systems. These key software and hardware components collectively provide the following key design features in the SIMnet client systems:

- H.323 Conferencing
- Audio and Video Support
- Virtual Instrumentation Support
- Office Automation
- Remote Administration
- Virus Protection

In the upcoming sections, the software and hardware components required to implement the key design features will be detailed. We begin the discussion with the software required to support the SIMnet client systems.

4.4.1 SIMnet Client Software

This section details the software components, which provide the client the ability to participate in the SIMnet system. Clearly, the client systems highest priority was to be able to participate in an H.323-based conference. The next subsection discusses the key H.323 components that the SIMnet clients use to support this participation.

4.4.1.1 H.323 Conferencing

The SIMnet client must fully support a H.323 compatible application. The Microsoft NetMeeting application provides the full suite of H.323 compliant features, and was chosen for the SIMnet clients. The shaded region in Figure 12 illustrates the H.323 protocol stack augmented by the Microsoft NetMeeting application and H.323 standard protocol elements.

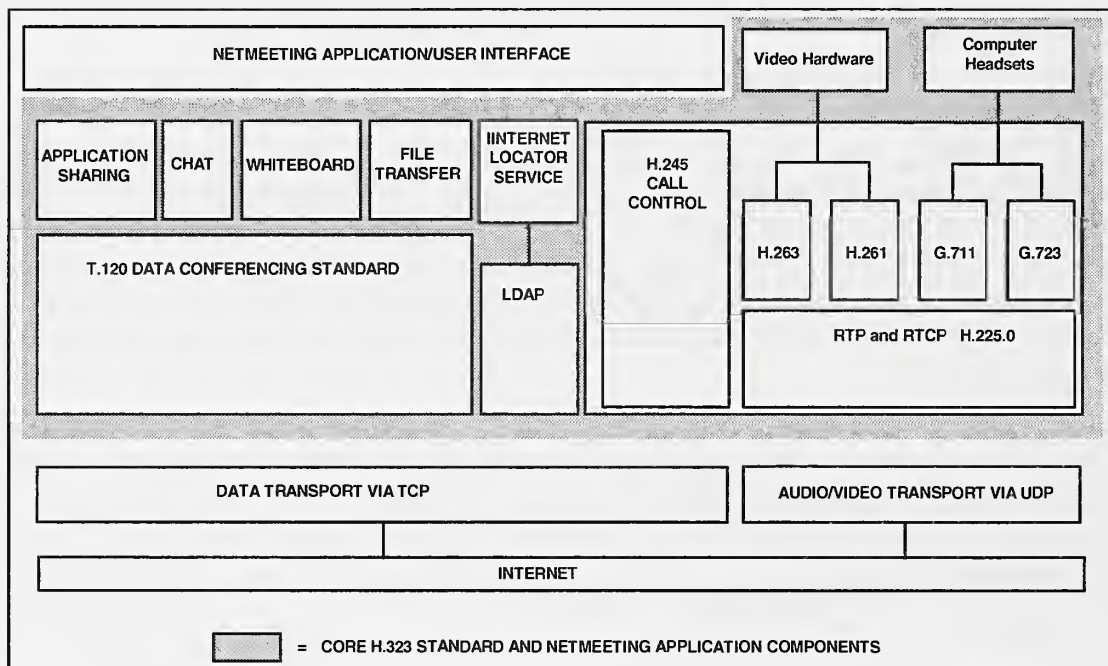


Figure 12: The Microsoft NetMeeting Support for the H.323 Architecture.

NetMeeting comes pre-packaged with various H.323 standards-compliant audio and video codecs (coder/decoders), which provides for the real-time audio and video element of SIMnet. Codecs are hardware and software components that encode their audio and video information from an original form into a standardized digital stream for transmission and subsequent use. The main application components of NetMeeting are shown in the shaded area to the left in Figure 12 and are instrumental in the SIMnet client system. These include application sharing, chat, whiteboard, and file transfer capabilities. The H.323 component protocol T.120 supports all of these data services in the NetMeeting application. The TCP/IP protocol is used underneath the T.120 protocol to transport the images/text of the data services provided by NetMeeting. The H.323 compliant T.120-based data services are classified as real-time although in practice the data services associated with NetMeeting operate in a best-effort processing mode.

Best-effort processing means that the system will make every effort possible to process, transmit, and display T.120 data in real-time and priority order. However, due to system overhead, network

latency, and protocol processing delays, the system may not be able to provide the data in real-time. If this occurs, the system does not fail, it merely retransmits data or recovers by some other means, perhaps by slowing down or stopping the video or audio traffic altogether.

Other H.323 compliant features of NetMeeting include the ability to support the sending and receiving of audio and video, online chat features, shared whiteboard, file transfer, and to share any locally executing application with other members of a SIMnet session. NetMeeting provides all of these capabilities with an intuitive graphical user interface for ease of use.

The ability to share a locally executing application is key to the SIMnet system. The primary reason for a SIMnet session is to provide measurement applications in a shared environment. During a SIMnet session a LabVIEW application, for example, is executed on Client A, and through the use of NetMeeting the application becomes shareable. All participants in the meeting are able to view the application as it executes. The "sharing" of an application is a salient feature of the SIMnet system, and is implemented using the T.120 protocol.

The online chat feature is another convenient T.120-based tool that provides an alternative means of communication. For example, if audio or video is disabled or not working, the participants can communicate with the group by typing in the text-based chat window. The target recipients of the chat message can either be the entire group (broadcast-based) or directed to a specific user. The real strength of chat however is that it provides a passive method for asking questions during a SIMnet session. For example, during a SIMnet session the host country and the other country involved in the international comparison are the only participants speaking. Other participants in the session are passively listening to and viewing the session. SIMnet meeting protocol dictates that only the two "speaking" participants should be heard and are the only participants visible in the video windows. The chat feature allows passive users to engage the active participants using a non-intrusive means of communication.

The shared whiteboard tool also uses the T.120 protocol and is commonly used as an "electronic notebook". The shared whiteboard allows users to capture any portion of the session and "paste" it into the whiteboard for shared real-time documentation of the event. Once activated, all users in the meeting see the whiteboard and can add information to it. Important items such as video images of who participated in the meeting, text-based notes, technical drawings or anything on the screen can be captured and used to document the session. Specific images of how to connect complex electrical equipment to the measurement system can be captured to the whiteboard by zooming the video camera in and taking a snapshot. Allowing participants to capture this information eliminates the risks of incorrect connections during future testing. This will also help to reduce the chance of accidents to the scientists, or damage to sensitive equipment.

The final T.120-based application used in NetMeeting is the file transfer capability. The file transfer capability is similar to the Internet-based file transfer protocol (FTP), for those familiar with this TCP/IP service. A file transfer capability is convenient if the host country has created a spreadsheet of measurements that they have just observed and would like to transfer this information to other participants. This capability allows all participants to instantly receive such a file. Such rapid dissemination of real-time information is an important aspect of the SIMnet system.

4.4.1.2 Audio and Video Support

In the case where the required amount of bandwidth is available, the use of audio and video can truly enhance the SIMnet session experience. Due to the data compression algorithms found in

NetMeeting, even bandwidth-limited connections can utilize some form of audio and video capabilities. For example, Internet dial-up sessions as low as 28 kilobits per second (kbps) can fully support all of the features of a NetMeeting conference. The rate at which video is presented to the user (frames per second) is slowed considerably at 28 kbps; nonetheless, in most cases clearly viewable pictures can be observed. A 56 kbps connection is recommended however for a good all around audio and videoconference experience.

When in a conference, NetMeeting's bandwidth management system places various priorities on sending audio, video, and data traffic. Using the bandwidth throttling and reservation capabilities in H.323 (the H.225.0 real-time protocol, RTP), NetMeeting raises the priority of audio over that of streaming video or data traffic. This makes sense, as it is more important for users to hear what is happening rather than view it, from the viewpoint of comprehending the activities in the session. In this case the operators audio is put through first, while video is synchronized to the current audio when the required bandwidth is available. The shared real-time T.120-based data traffic is also prioritized before the video traffic, allowing application data to be displayed before video traffic.

When using audio and video, it is important for the SIMnet clients to use identical hardware and software for the capture, digitization, and display of digital audio and video. As is the case with other standards, H.323 compatible products differ in their actual implementations. Implementation issues become apparent when using two different manufactures audio and video codecs to encode the data. H.323 based codecs encode and decode data based on standards defined by ITU. Audio codecs are based on the ITU G.7xy standards, where "xy" represents classes of audio quality from telephony to stereo quality. The video codecs, based on the ITU H.26x standards, where "x" represents different gradations that specify frame size and image quality. Both audio and video quality is ultimately based on available bandwidth. If a meeting must be held using lower bandwidth over the Internet, then an appropriate audio and video codec that uses higher compression rates such as G.723 and H.263, respectively, will be used.

The problem with communications involving different manufacturer codec implementations occurs when one manufacturer interprets the G or H ITU standards in a slightly different manner than another. Such differences often result in a negative impact on the quality of the audio and video. Therefore, for optimal performance of the SIMnet system, we have standardized on the use of a single audio and video product for use with NetMeeting. This does not imply that products from other vendors do not work together successfully. However, our testing has determined that we can achieve the highest quality using a single vendors family of codec-based products. The product we chose in the SIMnet system for audio and video codec support is the Winnov Videum AVI software and hardware.

The Winnov software includes device drivers for the Windows NT platform and is widely available. Our Internet-based research on codec products showed that Microsoft was using the Winnov product for video demonstrations at trade shows. In any event, our consistent use of the Winnov product on all clients eliminates the possibility that audio and video encoding/decoding incompatibilities will degrade performance of the system.

4.4.1.3 Support for Virtual Instrumentation

An important goal of the SIMnet design was to create a generic framework that supports the sharing of a wide-range of metrological applications. The collaborative capabilities of SIMnet make it a powerful tool in the metrology area. The application-sharing component of the SIMnet

design provides the underlying collaborative capabilities. The initial SIMnet testbed targeted support for the electrical measurement and calibration application domain. However, in the future, other domains such as the chemical, mass, and force metrology areas may also be addressed. In order to provide generic collaborative support for these domains, information technology-based mechanisms and protocols for application sharing is required.

Most measurement domains execute various instrumentation and control applications to capture, display and distribute metrological information. A way of sharing these applications in real-time between multiple parties using the Internet was needed. The generic mechanism used to foster application sharing in SIMnet requires the H.323-based T.120 protocol, which can be found in Microsoft NetMeeting. Using NetMeeting, any application can be shared over the Internet. Therefore, any measurement and control application that executes on a Windows platform can be accessible to many clients simultaneously using NetMeeting. Through the use of SIMnet, international comparison results in the electrical measurement domain are expedited by providing a standardized mechanism to simultaneously share these custom applications with others.

The Electricity Division within EEEL designs and develops in-house electrical calibration verification and control software using a LabVIEW development system from National Instruments. The resulting software executes on either Windows 95, 98, or NT system platforms. The LabVIEW verification applications supplement other measurement applications used during SIMnet-based international comparisons. The LabVIEW applications are called "virtual instruments" because of their ability to provide software-based control of hardware measurement instruments. A virtual instrument-based application used in combination with a PC-based National Instruments general-purpose instrument bus (GPIB) hardware board is capable of controlling a variety of measurement devices.

EEEL metrologists use a personal computer, GPIB hardware board, and their own custom designed LabVIEW virtual instrument applications to measure, calibrate, and control digital multimeters (DMMs) in their laboratory. For DMM testing, a testing procedure developed at EEEL especially for the SIMnet trials is used to sequentially execute the tests. Testing procedures for measuring voltage, current, and resistance are provided on the SIMnet Web site. The Web site provides the magnitude and frequency quantities to be used in the testing procedures. Data from the tests are stored in a password-protected area on the Web site. Figure 13 illustrates a DMM application used during a SIMnet session. The LabVIEW application is used to setup and control the test of a DMM using a characterized calibrator. The particular calibrator used in the example of Figure 13 is a Fluke model 5720A and is testing a Hewlett-Packard (HP) model 3458A DMM.

In order for other countries to execute the EEEL-developed LabVIEW applications and to successfully perform the NIST tests, the SIMnet client must have a Windows NT-based National Instruments (NI) device driver for the GPIB board installed¹². The device driver allows applications to interact with the NI GPIB hardware. We wanted to replicate the National Instruments-based measurement capabilities of an EEEL-based Windows NT system to all SIMnet clients. This would allow any SIM member country to act as the host country when performing a round-robin international comparison¹³.

¹² Device drivers are a system software component added to a system to allow application access to hardware in the system. In this case, the NIST LabVIEW application software uses the GPIB device driver to access the GPIB hardware board in order to communicate with DMM devices.

¹³ Round-robin international comparisons in the SIMnet system refers to the procedure of alternating host countries when performing the international comparison in order for all countries involved in the testing to complete their calibration requirements on a particular device under test.

The EEEL-developed verification software that performs these supplemental tests was not installed on each SIMnet client computer. This software changes frequently based on the types of devices being calibrated. Therefore, at any time during the testing phase, a SIMnet client may access the SIMnet Web site at NIST to download the appropriate LabVIEW verification application for a particular device.

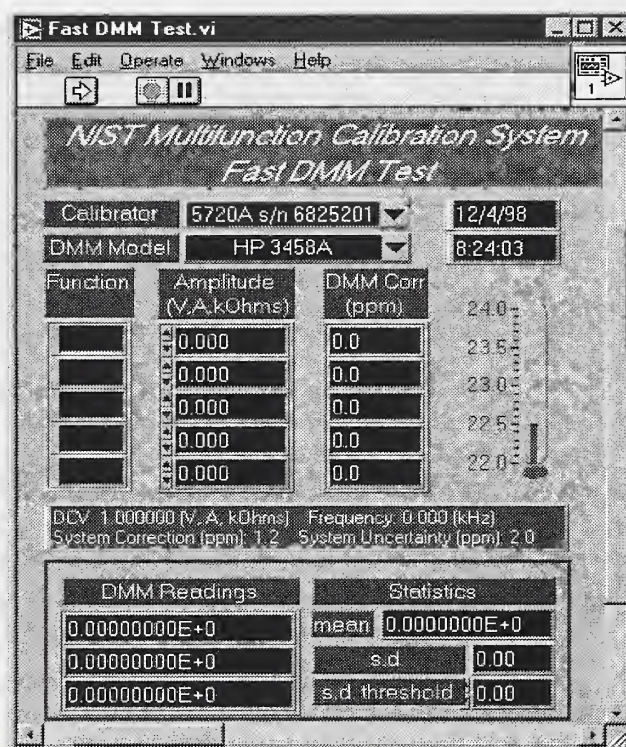


Figure 13: NIST calibration system can be used during SIMnet to verify DMM calibrations.

After the software has been downloaded and installed (via a short setup program), the host country configures the hardware under test and begins the verification session by executing the newly installed LabVIEW application. By doing this procedure during a SIMnet session, all participants bear witness to the actual measurement as it takes place in real-time. During the measurement, video images of the electrical connections and data are collected and saved so that others may document the test as well. This sharing of knowledge allows everyone to learn from the experience, while capturing the measurement data in real-time, thus expediting the overall international comparison process.

4.4.1.4 Office Automation Software

During SIMnet sessions the routine documentation and presentation of information would require a suite of office automation software. A spreadsheet program for example, could be used to view measurements while a database program stores the results. Word processors might be used to document the session. Presentation programs could be used for training sessions. Microsoft Office 97 provides a suite of programs providing the desired capabilities. The Office 97 programs consist of Word, Excel, Access and PowerPoint. All Office 97 applications can become sharable just as the LabVIEW applications are sharable in the SIMnet system.

We use PowerPoint internally at NIST for example, to demonstrate the SIMnet system to others. The demonstration begins by first dialing into the Internet and connecting to the SIMnet server using a notebook computer, NetMeeting, and a modem. The notebook computer then executes PowerPoint and shares a slide presentation using NetMeeting. All participants logged onto the server see and hear the presentation as it happens. Using this approach, we can present to multiple parties simultaneously the salient features of SIMnet by actually using the collaborative capabilities of the system.

4.4.1.5 Remote Administration

SIMnet by definition requires that client workstations be located at NIST and at the eleven OAS member countries. Although every effort was made to design the SIMnet clients to be as maintenance free as possible, system problems requiring intervention by the NIST SIMnet system administration team were inevitable. The SIMnet clients therefore were each equipped with Symantec's pcAnywhere remote administration and control software for Windows NT to handle such anomalies. Figure 14 illustrates the user interface of Symantec's pcAnywhere application.

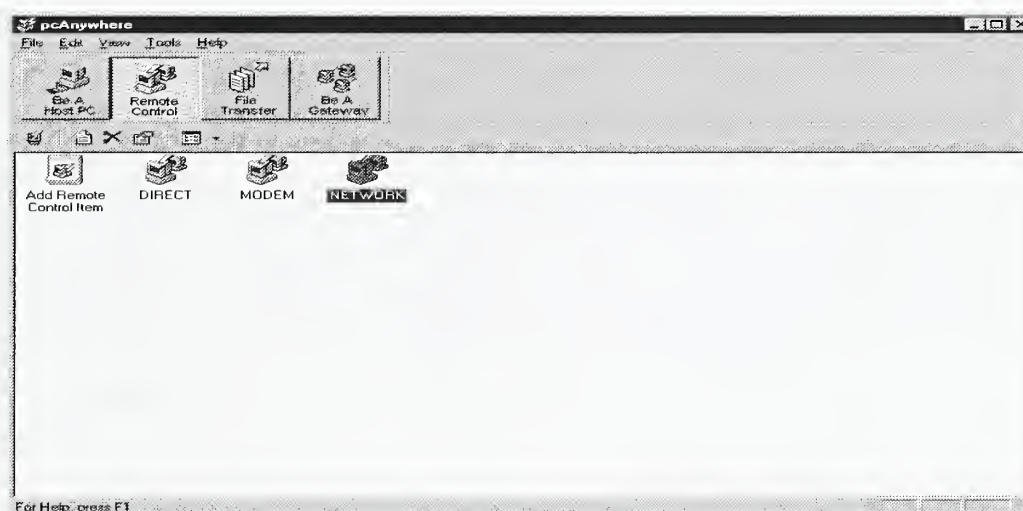


Figure 14: The user interface of Symantec's pcAnywhere.

PcAnywhere can be used across the Internet to gain access to a SIMnet client. Each SIMnet client system also contains a 56 kbps internal modem allowing the NIST team to dial directly into the SIMnet client system in the event Internet access is unavailable. This allows for remote administration of the SIMnet client. Once the NIST administrator dials into the client, the administrator is presented with the screen display of the remote client. In this way, remote support and maintenance or emergency administration can be performed. The use of the pcAnywhere capability was designed into the SIMnet client workstation to be used primarily for an "emergency" or "help requested" situation. In all other cases the member countries administer their own systems.

4.4.1.6 Virus Protection

Virus scanning software is present on all of the SIMnet systems. The SIMnet client systems should not download any information from the Internet except from trusted sites. The NIST Web site and various product Web sites are the only sites that SIMnet clients should use. Even trusted sites can in fact harbor viruses that could infect the SIMnet client.

We chose the Norton AntiVirus scanning software to protect the SIMnet client systems. The latest version of Norton AntiVirus has a convenient way to update the virus definition files over the Internet. The virus definition files are the heart of any virus scanning software package as they allow the scanning engine to search for the latest viruses. If virus-scanning software is not kept up-to-date, then the software cannot possibly check for and eradicate new viruses. The Norton updating procedure is called LiveUpdate™ and is used to access the Internet to download the latest virus definition files or product software updates.

The Norton AntiVirus scanning software on the SIMnet client machines was disabled from automatically executing at boot up due to the performance penalty it exacted when running continuously in the background. Therefore, by default the Norton AutoProtect feature (the background virus scanning process in Norton AntiVirus) was disabled. When not in a SIMnet session, system administrators may enable the Norton AntiVirus scanning feature or use LiveUpdate to download the latest virus definition files.

4.4.2 SIMnet Client Hardware

The SIMnet client hardware consists of off-the-shelf hardware and software components to support the SIMnet activities. Unlike the server component, the client systems are generic high-end desktop computers that have adequate amounts of RAM, hard disk, and CPU speed. In addition, the client computers in the field must support audio, video, and camera hardware for the conferencing portion of the SIMnet sessions. A general-purpose commercially available instrumentation board that supports the IEEE-488/GPIB communications protocol for data acquisition and control is required for performing the verification tests during electrical international comparisons. Additional peripherals include an internal 56 kbps modem, computer-based headsets, and an Ethernet network interface card (NIC) for LAN connectivity in the field. A description starting with the minimal requirements for the desktop hardware including CPU, memory, and hard disk is given. This section concludes with a description of the required peripherals for the SIMnet client workstations.

4.4.2.1 Central Processing Unit (CPU)

CPU requirements for a SIMnet client are based on the anticipated compute-intensive need of the audio and video processing subsystems, the amount of graphics to display, as well as the number of background applications expected to be simultaneously executing during a SIMnet session. As a rule, the amount of background applications was limited to only the necessary ones required to support the SIMnet conference session. In addition, a Web browser and Office 97 programs would also be required during the session. Therefore, because the Winnov Videum audio and video subsystem offloads the main CPU from direct processing interruptions, a number of background processes can coexist during a SIMnet session before significant degradation in performance occurs. However, the audio and video codecs require a highly compute-intensive environment. For this reason, the CPU requirements of the SIMnet client systems were specified very high. The Intel Pentium™ II processor (latest available at the time of order) with MMX™ technology executing at the highest possible clock speed was specified for the client systems. MMX technology includes an additional graphics-based instruction set that speeds up the graphics operations of the Winnov Videum subsystems and certain NetMeeting application areas.

4.4.2.2 Memory

Determining the amount of memory for the SIMnet clients became a question of estimating the memory requirements needed for the largest application in use on the client machine and using that number as a reference point. Again, more memory provides better results for the graphics-intensive types of applications found in SIMnet. In addition to the application requirements for memory usage, a minimum of 64 MB of RAM for Microsoft Windows NT was required. Therefore, given the relative low-cost of RAM, a typical metric with respect to specifying RAM is to double the largest possible application and operating system memory requirements. Thus, we specified the SIMnet clients to use a minimum of 128 MB of RAM.

Memory requirements for the client computers are not limited to the amount of physical RAM on the main system unit. The amount of video RAM or VRAM is also very important for graphics-intensive operations that are performed in conjunction with NetMeeting and the audio and video subsystems on the client computers. Therefore, balance the cost of VRAM with the amount of graphical computation expected in the system. The VRAM costs have kept pace with normal RAM (sometimes referred to as dynamic RAM (DRAM) or more often the newer type synchronous DRAM (SDRAM)). This means that a video card that contains as much VRAM as possible should be used for the SIMnet client systems. Unfortunately, video cards with a great deal of VRAM and that are capable of complex 3D rendering are extremely expensive. In some cases, a high-end video accelerator card can cost as much as 70-80% of the total cost of the computer. Clearly, this was not an acceptable alternative for the SIMnet client systems. Therefore, a balance between overall costs and reasonable video performance should be considered. Typically, a standard video card from a computer manufacturer such as DELL contains 8 MB of VRAM with upgrades to 16 MB costing an insignificant amount. Currently, the most cost effective amount of video RAM available that provides a significant increase in graphics performance is approximately 32 MB of VRAM.

4.4.2.3 Disk Subsystem

Unlike the SIMnet server, the specification of a SCSI configuration for the disk subsystem was not critical. A fast intelligent drive electronics (IDE) disk drive of reasonable size would be sufficient. In retrospect, if the SIMnet budget allowed, we would probably have chosen SCSI disk drives for the client machines as well to get around some of the annoying limitations in the disk operating system (DOS) basic input/output system (BIOS). Depending on the version of the BIOS, type of disk drive, and the capacity of the drive in the computer, several problems with partitioning disks can arise. These problems are caused by legacy limitations in the DOS file allocation strategies that lead to boot problems with disk drives having greater than 1,024 cylinders. SCSI disks avoid these problems because they can use a built in BIOS that bypasses the DOS BIOS during booting and likewise can cope with larger capacity disk drives. These issues did not affect the SIMnet client functionality, only the amount of system configuration overhead incurred during the initial rollout. The SIMnet client machines were specified with 10 gigabyte (GB) enhanced IDE (EIDE) disk drives.

4.4.2.4 Network Communications

Providing a variety of methods for allowing SIMnet clients to access the network was of paramount importance in the client design. This was implemented by providing both a network interface card for an Ethernet-based local area network connection and by installing an internal 56 kbps V.90 modem for dial-up connections. Allowing both dial-up and LAN-based communication provided

the necessary support to cover the three main requirement areas for network communication, namely, (1) provide a means for remotely administering the client machines, (2) allow the client machines to participate on the metrology centers' internal LAN via the Ethernet interface, and (3) provide a means for clients to connect to the Internet via dial-up using the internal modem and an ISP.

Some clients in the Americas connect to the Internet through an ISP using a dial-up 28 kbps or faster modem connection. This type of remote access communications allows the SIMnet clients to attach to the SIMnet server over the Internet using the dial-up internal modem connection. The internal modem was also needed to support a dial-in remote administration option from the NIST support team. In the event of a network failure, the internal modem could be used to directly dial into the client machine if serious administrative problems occurred. The internal modem was supported in Windows NT Workstation by configuring the remote access service (RAS) to use the modem for point-to-point protocol (PPP) dial-up capabilities.

The Ethernet interface was supported in order to allow the client administrators to connect the SIMnet client machines to their TCP/IP-based local area networks. The LAN cards were also convenient for testing, rollout, and the SIMnet Inaugural demonstration at NIST.

4.4.2.5 Audio and Video Support

The client workstations specified for connecting to the NIST SIMnet server support an audio and video subsystem that provides adequate real-time audio and video feedback during a SIMnet session. There are two minimums in hardware specificity that Microsoft recommends for supporting an audio and data sharing only capability, or an audio, data, and real-time video capability. We define the Microsoft minimums here for completeness and include the hardware designed for the SIMnet client systems. Please note that the Microsoft minimums are typically understated. This means that end system purchasers should at a minimum double the requirements stated by Microsoft. Also, you will notice that the hardware described later for the SIMnet testing far exceeds the minimums stated by the Microsoft NetMeeting Resource guide¹⁴. Areas where additional capacities are required will also be noted.

In order to use the data sharing and audio features of NetMeeting, your computer must meet the following minimal hardware requirements that are found in the Microsoft NetMeeting Resource guide:

- For Windows 95 and Windows 98, a Pentium 90 computer with 16 megabytes (MB) of RAM.
- For Windows NT 4.0 with Service Pack 3 or later, a Pentium 90 computer with 24 MB of RAM.
- Five MB of free hard-disk space; an additional 10 MB is needed, during installation only, to accommodate the initial setup files.
- 14.4 kbps or faster modem, Integrated Services Digital Network (ISDN), or a local area network connection.
- Sound card with microphone and speakers.

¹⁴ The recommended minimums are stated in both the Microsoft NetMeeting Resource Kit 2.1 and the newly released 3.0 version of the kit.

Data-conferencing features of Microsoft NetMeeting support null modem and TCP/IP connections. For real-time audio conferencing using SIMnet, you must use a TCP/IP network, such as the Internet or a corporate LAN.

To use the data sharing, audio, and video features of NetMeeting, your computer must meet the following minimal hardware requirements found in the Microsoft NetMeeting guide:

- For Windows 95 and Windows 98, a Pentium 90 processor with 16 MB of RAM; a Pentium 133 or later processor with at least 16 MB of RAM is recommended.
- For Windows NT 4.0, a Pentium 90 processor with 24MB of RAM; a Pentium 133 or later processor with at least 32 MB of RAM is recommended.
- Five MB of free hard-disk space; an additional 10 MB is needed, during installation only, to accommodate the initial setup files.
- 28.8 kbps or faster modem, ISDN, or LAN connection.
- Sound card with microphone and speakers.
- Camera with either a video capture card, universal serial bus (USB), or a parallel port connector that supports a Video for Windows driver.

NetMeeting works with any video card or camera that provides a Video for Windows capture driver. Some video cameras (digital) can plug directly into the parallel port or a universal serial bus connector of the computer if so equipped. Other cameras (analog) require a video capture card installed in the computer in order to digitize the analog input video signals. Camcorders can often be plugged into these capture card adapters and used as cameras as well.

In general, parallel port and USB cameras are less expensive but can be more CPU intensive, yielding decreased video performance. Cameras connected to video capture cards typically offer better performance. This is a result of the video capture card having an onboard dedicated video graphics processor that offloads processing from the main system CPU. Also, a black and white camera typically offers better performance during videoconferencing than an equivalent color camera, because less information is sent across the network connection. The videoconferencing camera system we chose for SIMnet is the Winnov Videum AV peripheral component interface (PCI) card and camera package shown in Figure 15 to provide the audio and video input to the NetMeeting client application¹⁵.



Figure 15: The Winnov Videum AV PCI videoconferencing board and camera set.

The AV stands for Audio and Video, and is one of the most powerful low-cost capture boards. One of the most important features about the Winnov product is that it provides tremendous audio

¹⁵ More information about Winnov audio and video products can be found at <http://www.winnov.com>.

capabilities such as full-duplex audio and guaranteed synchronization with the video capture card. Many video capture systems do not provide an audio subsystem, requiring the user to use the PC's internal sound card, which was not designed for intensive audio and videoconferencing applications.

Other important characteristics that were important for the decision to use the Winnov product include: superior performance for videoconferencing, integrated audio capture, multiple audio inputs for soundcard or headset, multiple camera support (up to three cameras) for multiple images, local and remote camera control of brightness, saturation, hue, pan, tilt and zoom, interoperable with any communication device: LAN, ISDN, modem, digital subscriber line (DSL) or cable modem, interoperable with all videoconferencing protocols (H.320, H.323, and H.324), specifically designed for Microsoft Windows NT, and finally it supports MMX-enabled CPUs for enhanced graphical performance.

When using NetMeeting and the videoconferencing hardware in noisy environments, or when hands-free communication is desirable, we recommend that headsets be used and in fact were a necessity for the SIMnet conferences. At the moment, the SIMnet client workstations use wired headsets from Andrea electronics¹⁶. However, for specific applications, investing in more expensive wireless headsets may be justified.

Wireless headsets provide much improved hands-free communication during the calibration series or measurement operations that require frequent physical activity. The Andrea headset has been made specifically for computer-based applications and includes a boom-mounted microphone. The Andrea NC-65 headset is shown in Figure 16. Although the headset cord was lengthy, an additional cord adapter was also used on each SIMnet client system to improve operator mobility.



Figure 16: The Andrea Electronics NC-65 computer-based headset used in SIMnet.

The Andrea headset connects directly into the Winnov Videum AV PCI board. The Winnov board includes sound card functionality as well as microphone input for the headset. The combination of the Andrea headset with the Winnov Videum card provided extremely good audio and video quality. Because all the SIMnet client computers used the exact same hardware for videoconferencing, the chance of interoperability problems with audio and video codecs was eliminated.

¹⁶ More information about Andrea Electronics headsets can be found at <http://andreaelectronics.com>.

Once the hardware is standardized, other very important issues surface, for example, discovering the appropriate parameters and configuration settings for optimal videoconferencing using Microsoft NetMeeting and the Winnov hardware must be found and maintained. A major problem we found with deploying these types of systems is that numerous settings for both the application software as well as the hardware can be chosen. Any slight deviation in any of them could cause quality, connection, or other problems during a SIMnet session. Therefore, it was imperative that SIMnet participants familiarize themselves with how to set the correct settings and more importantly, that they all agree to universally use the standardized settings during a conference.

4.4.2.6 Virtual Instrumentation Hardware

The SIMnet client hardware was required to support the capture, manipulation, and display of electrical measurement information. Each client system supports this capability in order to perform round-robin electrical international comparisons within each subregion of SIM. The choice of hardware for the electrical measurement domain was dictated by replicating the facilities in use by metrologists within EEEL at NIST.

Researchers at EEEL routinely use and develop application software for the National Instruments, or NI IEEE-488.2 GPIB board. Therefore, each client was required to support a NI IEEE-488.2 GPIB hardware data acquisition board for a Windows NT Workstation-based platform¹⁷. The NI GPIB hardware board was needed to provide each SIMnet client with the ability to support the NIST LabVIEW measurement and control verification application environment. Figure 17 illustrates the Windows NT version of the National Instrument GPIB PCI-based board.

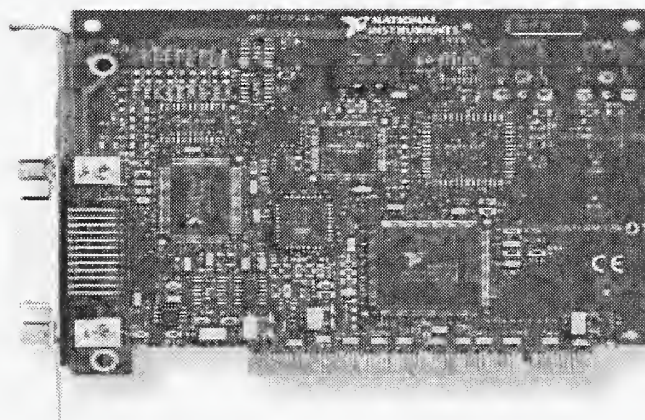


Figure 17: The National Instruments IEEE-488 GPIB hardware board for Windows NT.

Many National Measurement Institutes (NMI) such as NIST use GPIB hardware boards during SIMnet sessions to locally communicate with their measurement applications. The DMM's are physically connected to the GPIB hardware to form a device bus-based control network with other devices (i.e., DMM, calibrator, and PC with GPIB board). These devices attach to the network for sending and receiving commands and status information during an international comparison. The devices are used to capture, control, and test various DMM characteristics using the calibrator. A typical DMM testing setup is shown in Figure 18. Here the device under test, an HP DMM model 3458A is connected to a Fluke model 5720A calibrator.

¹⁷ More information about the National Instruments Windows NT-based GPIB NI-488 hardware can be found at <http://www.natinst.com/products>.

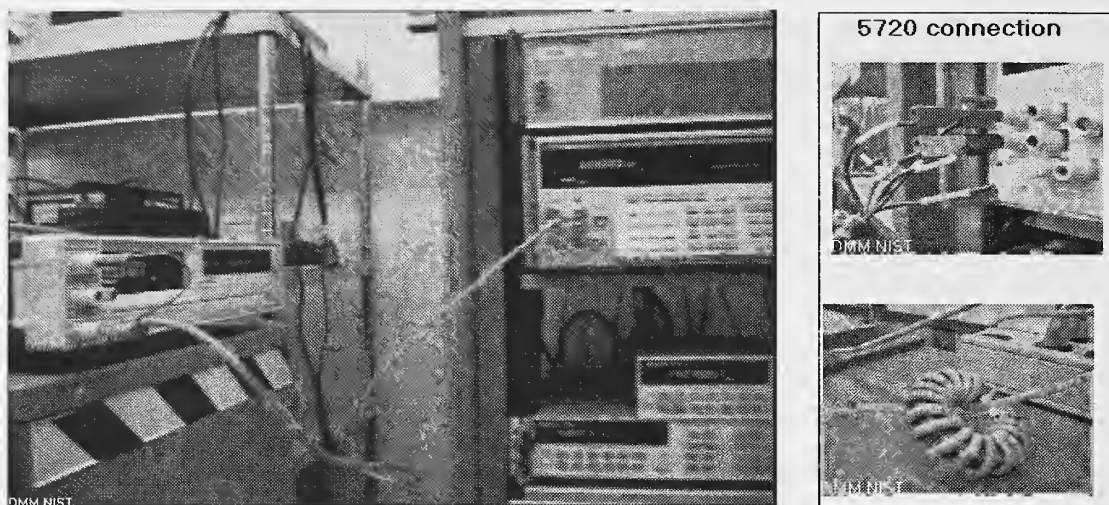


Figure 18: A typical DMM testing setup at NIST using HP and Fluke equipment.

Both devices connect to a GPIB-based bus communication network that ultimately connects to the GPIB card in the Windows NT computer. The images in Figure 18 were actually taken using the Winnov Videum camera. The close-up photos of the connectors illustrate the types of images that can be very useful during a SIMnet session to show participants in real-time how the connections and the various equipment should be used.

By combining each client system with the GPIB hardware and the EEEL-developed LabVIEW applications, all clients in the field have exactly the same PC-based testing and verification capabilities as those in the EEEL laboratory. After the metrologist download the application to their machine, a simple setup program installs the verification program. The metrologist then executes the DMM application which contains all LabVIEW support packaged within the DMM application environment.

The client systems do not need to have an individual licensed copy of LabVIEW to execute the EEEL-developed applications on their systems. An interesting packaging feature with the LabVIEW software development environment allows EEEL researchers to “compile” the DMM virtual instrument-based application to a form that includes a binary runtime image of the LabVIEW executable program. The compiled image includes all the necessary LabVIEW runtime support required to execute the DMM testing applications locally. Together with the installed NI GPIB board, a complete testing environment for the electrical measurement area is provided on a cost-effective platform. National Instruments provides this packaging capability royalty and licensing free for up to 30 end-users. This approach to LabVIEW licensing for the DMM distributed applications satisfies the current SIMnet requirements. However, in the future, a more flexible licensing arrangement or application delivery mechanism will need to be negotiated with National Instruments.

The licensing issues discussed here reflect an important area of concern when rolling out systems such as SIMnet. Licensing of software to multiple parties requires stringent distribution and delivery mechanisms in order to control access and to maintain legal licensing objectives. Currently, SIMnet enforces password protection to access the applications from the SIMnet Web site. Other controls will need to be put into place as the SIMnet system and others like it continue to grow in popularity.

5 SIMnet Pilot System

The SIMnet pilot system was to serve in many capacities during its evolution. First, it would serve the design team as a testbed for configuration and functional testing. Second, this same system once configured and operational would serve as a training site for OAS personnel participating in the SIMnet Inaugural. Finally, this new fully functional and tested system would have its client computers dispersed to remote locations, and would serve as the true SIMnet pilot system.

This section details the many aspects of the SIMnet pilot system evolution. In Section 5.1 we discuss the teaming efforts that made this project a success. In Section 5.2 we detail the hardware and software specifications of the pilot system. In Section 5.3 we discuss the staging and configuration methods followed for this project. In Section 5.4 the initial functional testing is covered.

5.1 Teaming

As one may expect, procuring, building, configuring, and deploying a system as large as SIMnet requires a team of dedicated administrators and computer support personnel. A wide-range of talents was required from procurement assistance, installation, technical administration, and configuration, to preparing the SIMnet client computers for shipment to their destinations. In support of the development effort, the Manufacturing Engineering Laboratory's System Administration (MELSA) group was called in to help with this phase. As a group within the MEL, MELSA provides day-to-day system administration, procurement support, and PC maintenance duties to the MEL network and computer infrastructure at NIST. They have experience in network design, system administration, and general computer support duties for Unix, Windows NT, and Macintosh hardware and software.

MELSA provided assistance in ordering, installing, configuring, deploying, shipping, and implementing many of the support features discussed in this document. Anyone contemplating building such a system on the scale of SIMnet must have access to the administrative and logistic capabilities possessed by a group such as MELSA. This includes a project leader with a minimum of five technical support personnel to meet an aggressive deployment schedule. The technical personnel must be capable of building, installing, configuring, and administering Windows NT-based workstations, servers, and networks. Coordinated support is critical to successful deployment and support efforts with these types of systems. MELSA personnel working in unison with NIST researchers from both EEEL and MEL combined their knowledge and efforts to help realize the SIMnet system.

In addition to the system administration team, several key EEEL personnel were required during the usability and testing phases of the SIMnet system. The EEEL members provided expertise in the metrology applications that are used in the SIMnet pilot system. These "end-user" advocates and LabVIEW application experts were essential in ensuring that the solution met the needs of the SIMnet metrologists performing the standards international comparisons.

Building teams and relationships with the right people for the task at hand is likely the most important step in realizing a large and state-of-the-art undertaking such as SIMnet. In addition to support personnel, relationships must be made during the testing period with vendors of the core products that make up the SIMnet system. A great deal of collaborative effort between NIST and

PictureTel transpired on this project. Building a relationship with PictureTel for feedback on problems, information, and upgrades during the testing and development phases was instrumental to the success of SIMnet. Such relationships help both the customer and vendor. This partnering works because the customer expediently obtains answers to problems, while getting access to early release software for future integration and testing. The vendors like this relationship because they get feedback from customers using their products. Likewise, customers provide vendors with information about how to improve, modify or revise the current product offering based on their experiences with product usability and performance. Collaborating with a vendor this way typically manifests itself through what is termed “beta testing” a product. Beta testing products involves installing and using a pre-release product in order to evaluate usefulness, interoperability, or suitability to a particular application domain.

NIST, specifically MEL, maintains a beta site-testing environment for the PictureTel 330 product line among others. In that role, NIST provides PictureTel with valuable feedback about current and upcoming releases of their PictureTel 330 product line. In this relationship, NIST obtains early releases of the 330 product for testing compatibility, performance, and interoperability. During beta testing, several issues with the PictureTel 330 product have been found and relayed back to PictureTel. Many issues are caused by inherent H.323 implementation differences between Microsoft NetMeeting and the PictureTel 330 product line¹⁸. In any event the beta test relationship between NIST and PictureTel has helped tremendously in discerning problems with the SIMnet environment.

5.2 Specifications

For the purposes of our discussion, the testbed development phase defines the hardware and software specifications used for purchasing, installing, and testing a prototype SIMnet system at NIST¹⁹. It is important to note that the specifications as described herein are based on a procurement that commenced in August of 1998. Therefore, the specifications for the hardware and software reflect the state of availability at that time. Clearly, with the passing of time and changes to software and hardware requirements, sufficiently updated specifications should be researched by anyone designing a SIMnet-like system.

5.2.1 Hardware

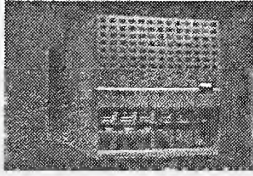
The SIMnet server was required to support the 12 OAS nations. At the time, the PictureTel 330 software supported either an 8-port or 24-port version. Therefore, based on the number of ports needed by the OAS participants, we chose the 24-port version of the software. We then based the initial server hardware requirements on the PictureTel 330 24-port minimal requirements and sized up accordingly. The hardware required to support a maximum of 24 users in the PictureTel 330 NetConference server environment is shown in Figure 19 and includes:

Server: DELL PowerEdge 6300 Server with 2 (Quad CPU capable) Intel Pentium Xeon 400 MHz CPUs. Three 9 GB SCSI RAID disk drives. 1 MB of RAM per CPU. 1MB of L2 cache for both Xeon CPUs. Windows NT Server 4.0, Service Pack 3, Option Pack 4.0.

¹⁸ For example, on some occasions when a Microsoft NetMeeting client attempts to connect with the PictureTel 330 server, the connection process may not complete properly. In this case, the PictureTel 330 server may not gracefully terminate the connection, thereby requiring the system to be rebooted.

¹⁹ A complete itemized listing of the software and hardware used for the SIMnet clients and server can be found in Appendix B.

DELL POWEREDGE 6300



Available with Intel's 400MHz Pentium® II Xeon processor featuring a 512k or 1MB level 2 cache, the PowerEdge 6300 is prepared to meet your application server needs with a powerful combination of performance, availability, scalability, and manageability found on no other system of its class. The PowerEdge 6300 is FCC-A certified for commercial usage only.

For a limited time, get a PowerEdge Expandable RAID Controller at no additional charge!

► STORE MENU

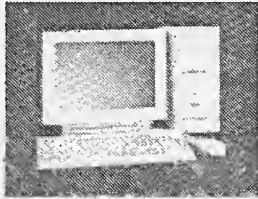
► STORE HELP

► YOUR CART

Date:	Wednesday, August 19, 1998 11:52:02 AM CDT
Catalog Number:	04 Retail
PowerEdge 6300 System:	PowerEdge 6300, 400MHz, 1MB Cache, Redundant Power Supply 634001 - [220-0441]
Processors:	Dual Processors (1MB cache) 2P4001M - [311-0563]
Memory:	512MB RAM, 4 X 128 EDO DIMMs 512M4D - [311-0476]
Keyboard:	Windows Performance Keyboard P - [310-7004]
Monitor:	Ultrascan 1000HS, (16.0"VIS) 10TM - [320-0056]
First Hard Drive (all drives must match in size):	9GB Ultra-2 LVD SCSI 7200 RPM Hard Drive 9LVD - [340-0596]
Secondary Controller:	PERC RAID, 16MB Cache, special promotion price P16 - [460-0883]
Diskette Drive:	1.44MB Diskette Drive FD - [340-0608]
Operating System:	Microsoft Windows NT Server 4.0 NTS40CD - [430-2185]
Mouse:	Microsoft Mouse MD - [310-0017]
Network Controller:	IntelPro 100+ PCI ENET NIC IN100P - [430-0111]
Tape Backup Drive:	DDS-3 12/24GB Tape Drive DDS3 - [340-0609]
CD ROM:	14/32X SCSI CD-ROM CD32X1 - [313-0252]
Second Hard Drive (all drives must match in size):	9GB Ultra-2 LVD SCSI 7200 RPM Hard Drive 9LVD - [340-0596]
Backup Software:	Seagate Backup Exec 7.0 for NT/NW - Single Server BE7XSS - [340-0477]
Hard Drive Configuration:	RAID 5, Requires a RAID Controller C5RAID5 - [340-0634][340-0634]
Chassis Style:	Tower Style (rubber feet) TOWER - [310-0181]
Service:	3 Year limited warranty, 1yr on-site, 2yr parts S3W - [900-1300][900-5112]
Third Hard Drive (all drives must match in size):	9GB Ultra-2/LVD 7200 RPM SCSI Hard Drive 9LVD - [340-0596]
Hot-Swap Hard Drive Backplane:	6 Bay Hard Drive Backplane, 1.6" or 1.0" 1X6BKPL - [311-0485]

Figure 19: The SIMnet server specifications obtained from the DELL Web Site.

Clients: In total, 14 client workstations were ordered for the SIMnet system, including 12, one for each OAS member country and 2 spares for backup, testing, or contingencies. For the client computers, DELL 400 MHz Dimension XPS-R Pentium-class computers capable of supporting Windows NT Workstation 4.0 were chosen. Each system included 128 MB of RAM and 10 GB disk drives. Figure 20 illustrates the exact specifications that were obtained from the DELL Web site and were subsequently used to order the client machines.



DELL DIMENSION XPS R

Built with high performance and reliability in mind, the Dell Dimension XPS R series use the latest in technology to deliver the tremendous speed your high-end applications are craving.

► STORE MENU

► STORE HELP

► YOUR CART

Date:	Wednesday, August 19, 1998 12:03:47 PM CDT
Catalog Number:	16 112233
Dell Dimension XPS R400 MiniTower:	DIM XPS R400MZ,PII,MMX,512K,MT GR400S - [220-0437]
Memory:	128MB ECC 100MHz SDRAM 1 DIMM 128ECC - [311-0413]
Keyboard:	Spacesaver Windows 95 Quietkey Keyboard W - [310-7002]
Monitor:	1200HS Monitor, 17.9 inch Viewable Image Size 12HG - [320-0222]
Video Card:	ATI XPERT 98D, 8MB, 3D, AGP 2X Video Card 8AGPATI - [320-5433]
Hard Drive:	10.1GB EIDE Ultra ATA 10 - [340-7721]
Floppy Drive:	1.44MB Floppy Drive 3 - [340-7016]
Operating System:	Windows NT with Internet Explorer 4.0 CD NTIE4 - [420-0155][420-6111]
Mouse:	Microsoft PS2 Intellimouse IM - [310-0050]
Network Card:	3COM,3C905B PCI 10/100 3C5B - [430-3034]
Modem:	56K Capable Modem, x2, w/Data/Fax/Voice MO56SND - [313-0896]
CD-ROM:	17/40X EIDE CD40 - [313-1087]
Sound Card:	Integrated Crystal Wavetable IS - [313-4523]
Speakers:	Altec Lansing ACS295 Speakers ACS295 - [313-3612]
Bundled Software:	MS Office '97 CD - Small Business w/Encarta (Win NT) SBE97EN - [412-0078][412-0071]
Storage Products:	1omega ZIP, EIDE, includes TWO zip disks for Windows NT FZIP2NT - [340-2406]
Free! A \$65 Value!:	No McAfee Virus Scan 3.1 NOMCAFE - [460-6500]
Service:	3 Yr NBD On-Site W3OS - [900-1550][900-1552]
Web tracking code for Internal use:	ESL on-line order WWW - [460-9052]

Figure 20: The SIMnet Client Specifications from the DELL Web Site.

As part of the budget requirement, the goal for procuring the SIMnet client systems was to keep the total cost per unit below \$3,000.00 USD. This cost basis has been met resulting in reasonably priced workstations that provided a tremendous price/performance benefit. At the time of this writing, the cost of a comparable machine from DELL has dropped to approximately \$2,000.00 USD. Each DELL standard as well as third party components in the client systems that were configurable during the ordering process are individually detailed in the following list:

1. 3Com 3C905B 10/100 mbps Ethernet Network Interface Card (NIC). Used to connect to the internal TCP/IP-based local area network (LAN) of a SIMnet metrology center.

2. Crystal Wavetable integrated sound card package. This package was not used during the SIMnet sessions. The Winnov audio/video add-in card (see item 9) for videoconferencing supplanted the integrated sound card features.
3. 40 X CD-ROM Drive, supports software installation and upgrades of the client computers.
4. Altec Lansing Speaker Set
5. 19" Sony Trinitron Monitor
6. 100 MB Iomega Zip Drive
7. 1.44 MB Floppy Disk Drive
8. Microsoft PS/2 Intellimouse™
9. Winnov AV Videum Pro Conference Packages (PCI-based). This is an analog camera w/integrated microphone and includes a video card for the camera. The Winnov package fully supports the Windows NT 4.0 Workstation operating system (P/N 60-0027).
10. Andrea Electronics NC-65 headset. The Andrea NC-65 headset is a low-end model available in many computer retail stores. The NC-65 headset is adequate for the SIMnet conferencing sessions. The headset eliminates background noise with echo cancellation techniques to provide a more enjoyable conference in a noisy laboratory environment.
11. Diamond Supra Express 56 kbps internal V.90 modems for dial-up Internet connectivity. The modems would also be used to support a direct dial-in feature for remote administration capabilities.
12. National Instruments PCI GPIB and NI-488.2M (IEEE 488) for Windows NT. Part number 777073-01. These cards allow the EEEL-developed virtual instrument-based LabVIEW verification applications to access the DMM measurement hardware under test. Each SIMnet client must support this capability, as each client would eventually participate in round-robin international comparison sessions at one point or another.

5.2.2 Software

This section details the software required to support both the server and client configuration in the SIMnet system. The server software component procured was based on the decision to support the PictureTel H.323 NetConference Multipoint conferencing server Version 1.01, 24-port license option. The client systems were installed with the requisite software to fulfill the key design requirements in the SIMnet client environment including: H.323 Conferencing, Audio and Video Support, Virtual Instrumentation Support, Office Automation, Remote Administration, and Virus Protection. Therefore, the following software items were used to support both the server and client SIMnet systems:

Server: The Microsoft Windows NT Server 4.0, Service Pack 3 operating system was used on the DELL PowerEdge 6300 server and was bundled in with the DELL hardware order. The only

SIMnet operational software on the server machine is the PictureTel 330 NetConference Multipoint Server Software Version 1.01 (24-port license). The Seagate Backup Exec Version 7.0 was used on the server with a tape drive unit to provide backup facilities on the server.

Clients: The Microsoft Windows NT Workstation 4.0, Service Pack 3 operating system was used on the DELL SIMnet client systems. The Microsoft Office 97 Professional SR-2 (Service Release 2) was installed in support of the office automation software requirements. Remote control and administration capabilities required Symantec's pcAnywhere Remote Control Version 8 software. Anti-virus protection was enabled using the Norton AntiVirus Version 5 software package.

5.2.3 Ancillary Hardware and Software

During the prototype testing and deployment process, there were varying amounts of ancillary hardware equipment and software products used to support the initial trials. The items discussed in this section were not part of the SIMnet official deployment. However, these items were necessary to support preliminary installation, internal testing, and the subsequent rollout of the SIMnet system. Therefore, for completeness, the combined hardware and software ancillary items required to support the initial SIMnet configuration and testing environment are included here:

Hardware

- Fore Systems ES-3810 10/100 Mbps Ethernet Switch. This is a high-end Ethernet switch from Fore Systems that was used during the prototyping and testing phase to create a high-speed intranet capability for a best-case videoconferencing scenario for testing and performance monitoring. This configuration provided the NIST SIMnet beta testing team with empirical knowledge about how the SIMnet system would perform in the best-case environment. Lessons learned from these trials were used to test and tune the SIMnet system for less capable settings. Issues with H.323 connection setup, network latency, timeouts, and throughput concerns could be tested before actually deploying the system to the field.
- (12) 25' RJ-45 Category 5 100 mbps Belden networking cables. These cables were used to create a prototype 100 mbps switched Ethernet testing environment by connecting the 12 client systems directly to the Fore Systems Ethernet switch.
- CD-ROM rewriteable device for creating hard disk installation images, backup CD-ROMs of critical software, and for developing the bootable support and maintenance CD-ROMs for updating machines in the field.

Software

- Norton Ghost Version 5.1. Ghost was used to provide the bootable CD-ROM disks. The bootable CD-ROM disks as well as the normal maintenance CD-ROM disks were provided as part of the support plan for SIMnet. Ghost provides the capability to clone hard disk images to a CD-ROM. This provides an efficient means of deploying several workstations at once using a standard configuration. Ghost was used to rollout the identical SIMnet systems using the CD-ROM method of rapid deployment.

5.3 Staging and Configuration

Assembling all of the hardware and software components discussed in Section 5.2 into a working system took place by first staging the systems, and then configuring the components of the system.

Staging the SIMnet system is discussed in Section 5.3.1. The configuration steps taken are discussed in Section 5.3.2.

5.3.1 Staging

The range of software assets required for the SIMnet application included, in addition to the PictureTel 330 server software, a database of logs, backup software, and Web Server technology. Staging the SIMnet server application with all of these assets on the server machine required: operating system installation, burn-in, and system application installation. The Windows NT Server 4.0 operating system was initialized on the RAID SCSI disk drive from its pre-loaded image state²⁰. The server then went through a system configuration phase where all network, security, and other administrative facilities were configured for the environment in which the server would operate.

Upon successful completion of the server operating system software installation, a reasonable amount of time was provided for the actual server “burn-in”. Burn-in refers to allowing the hardware and software of the basic machine to run for a specified amount of time with no functional capabilities used. Typically, any defects (i.e., hard disk failures, CPU heating failure, memory errors, missing parts, or errors in the complementary metal oxide semiconductor (CMOS) setup) present themselves during the first 48 hours of the system burn-in period.

The staging process normally occurs on one or more computers that are isolated from any other production network and computers, so that any problems exposed during testing do not impact sites that have already been released. The staging process concludes with final installation, configuration, and execution of the PictureTel 330 NetConference Server software and its associated system components. The next several subsections discuss the configuration process in detail.

5.3.2 Configuration

All software that is used during the configuration process should typically go through a data center approval phase before being released. However, since this system was in beta, we had the luxury of forgoing any formal data center approval activities. We did however maintain concise documentation with the data center of all software used in the system to facilitate any future re-installation or maintenance processes that were bound to occur.

We began the configuration process by assembling and configuring the software and hardware required for the SIMnet server and client systems. In general, the configuration process focused on three key areas: (1) configuration of the server, (2) configuration of the clients, and (3) connecting the clients to the server via the network for the upcoming testing phase.

5.3.2.1 Server Configuration

After burn-in and final configuration of the Windows NT Server 4.0, the software-based videoconferencing server package from PictureTel was prepared for installation. In preparation for

²⁰ The “preloaded” state refers to the way in which DELL systems are shipped from the factory. As part of the factory installation, DELL partitions the system disk drive into two areas: one consists of a 2 GB DOS FAT partition that contains the operating system installation image, and one other partition formatted for the Windows NT File System (NTFS). During system initialization, the operating system files are installed and made operable using the first 2 GB partition. Many system administrators delete this information and re-partition the disk drive and load all system files from the included CD-ROM media.

the PictureTel 330 software installation, an inventory of software and libraries that needed to be present on the server prior to the PictureTel 330 installation was taken. These include NTFS support, TCP/IP networking, SNMP, ActiveMovie, and DAO components. After the successful installation and configuration of these components, the PictureTel 330 software could be installed on the DELL PowerEdge 6300 server using the provided CD-ROM media. As part of the licensing component of the PictureTel 330 software, a hardware-based parallel port key is installed on the DELL server. If the key is not installed on the server the software will not function correctly. In addition to the PictureTel server software, individual applications were required to be customized in support of the server program. Web server software, database components, and networking software were all configured on the server in support of the multipoint conferencing server software.

After the PictureTel 330 server software and its associated components have been installed and configured, one configures virtual rooms on the Internet that users “connect” to using IP addresses. As part of the PictureTel 330 configuration process, the virtual meeting rooms must be correctly setup to support the specific audio and video codecs (encoding/decoding) for the Microsoft NetMeeting H.323 client application. Any H.323 compliant client can be used to connect to the server, however we were using the NetMeeting client exclusively.

In order to manipulate the virtual rooms and their associated parameters, the PictureTel NetConference Administration Console application was used to configure the virtual meeting rooms on the SIMnet server (see Figure 11, page 34). Currently, the SIMnet server’s 24 ports have been partitioned into two virtual meeting rooms called *SIMnet1* and *SIMnet2*. *SIMnet1* can support up to 15 users and is the official SIMnet meeting room used for electrical international comparisons between SIM subregions. *SIMnet2* can support 9 users and is primarily used for testing and ad hoc meetings. Both rooms are currently marked as public.

5.3.2.2 Client Configuration

The client configuration process first identified one of the 14 client computers as the “master” configuration computer. The master computer was then configured with all requisite SIMnet hardware and software as a fully functioning SIMnet client computer. Many configuration errors that occur during the installation of hardware and software from different vendors can be found and rectified during this process. The diagnostic tools that will be discussed in Section 6, can aid in properly identifying configuration problems. The master also had all third-party device driver updates, service packs, and hot-fixes applied as well. Upon completion of the master computer configuration, a CD-ROM was created that mirrored the image of the master computer system disk drive.

The disk mirroring was done using the Norton Ghost utility. Administrators use Ghost to create bootable CD-ROM images of a complete master configuration hard disk drive. Using the newly created CD-ROM, administrators can begin a “cookie cutter” approach to rolling out the other SIMnet clients. In a matter of minutes using the network as the distribution point, the disk drive image of the master computer can be downloaded to all the machines at once. As an alternative, each individual SIMnet client computer can be updated with Ghost by inserting the Ghost disk into the CD-ROM and rebooting. Of course, once the machines were cloned to look like the master computer, several key configuration parameters (computer name, network parameters, etc) were required to be changed.

A key feature of Norton is that it automatically assigns different Security Identifiers (SIDs) to the administrator as well as other users on the computer. Microsoft warns that identical SIDs on a standalone workstation (which was the way we configured the SIMnet client computers) has security risks. To avoid this, the Norton tool generates new SIDs for each cloned workstation. This was important because the computers were being rolled out initially onto the same network for our testing and demonstration. More importantly however, because each computer was eventually to be shipped abroad to different countries, basic SID security was a concern.

With a disk cloning procedure identified, work began on configuring the master client machine. The basic Windows NT Workstation 4.0 operating system configuration options were completed. The administrative configurations include setting up the special access logon accounts for the various user levels on the system. Each SIM metrologist, associated computer administrator, and NIST SIMnet support personnel were all given logon accounts on the SIMnet client workstations. The logon accounts varied only in the degree to which administrative capabilities on the client machines could be carried out.

As part of the normal Windows NT configuration process, the video display driver typically requires a re-configuration in order to change from the standard video graphics array (VGA) default setting to the current video card in the machine. These were updated and the proper resolution and size of the screen was set to an optimal setting. This may seem like an insignificant point, however, the display performance and efficiency of NetMeeting was determined by optimal settings of the local machine display characteristics as dictated by the Winnov audio/video subsystem. For our particular case, a screen resolution of 1024x768 with True Color was the optimal settings for the video subsystem to operate efficiently.

After normal configuration of the Windows NT Workstation was completed, the SIMnet related application programs were installed and configured on the master computer. These included the Winnov hardware and software, Microsoft NetMeeting, National Instruments GPIB hardware and software, Office 97, Symantec's pcAnywhere, and the Norton AntiVirus package. The client machines were considered standard configuration computers with off-the-shelf components, and it was not expected that a great deal of setup preparation would be needed. For the most part, this was the case, however, several configuration issues arose which took a considerable amount of time to research and solve.

Briefly, some of the issues found during the master computer installation include: Interrupt ReQuest (IRQ) conflicts, memory address and I/O conflicts with most hardware peripherals, late breaking device driver updates and patches for the Winnov card, device driver support problems with the DELL installed WinModems, network and remote access service (RAS) bug fixes, and errant internal sound card interaction with the Winnov audio subsystem. It must be stated that most of these problems occur due to the fact that Windows NT Workstation 4.0 is *not fully* plug-and-play compatible. As a result, the hardware peripheral conflicts could not be avoided. As for the rest, most of the issues required research on vendors Web sites and knowledge bases as well as intuitive understanding of the Windows NT system in order to resolve the problems. The relevant system settings are specific to the hardware purchased for SIMnet and were provided as part of the training session. These settings however are not provided here as they are not universal and only apply to this particular case.

Prior to rolling out the client machines with Norton Ghost, the remaining computers were put under the same pre-configuration requirements as the server. The client machines underwent a 48-hour

burn-in period. After the burn-in period, the remaining client machines were replicated using the Ghost utility. The client machines were now ready to be attached to the network for preliminary testing.

5.3.2.3 Attaching to the Network

A high-speed (switched 10/100 mbps Ethernet) local area network-based intranet was setup to test the 12 SIMnet client connections with the server. In order to support the server connections over the network, the client computers were configured with 3Com 3C905B Ethernet cards and the TCP/IP protocol. In addition, the internal modem was configured to provide a dial-in capability for testing low-speed Internet connections. To support both types of networking conditions, a general TCP/IP networking configuration using Ethernet and dial-in access via RAS was provided. RAS required the installation of the internal hardware Diamond Supra 56 kbps V.90 modem. RAS was temporarily configured to use a special dial-in account at NIST to test the installation and connection to the Internet using the point-to-point protocol (PPP). A substantial amount of time was spent finding the right combination of RAS configuration settings and the inherent TCP/IP settings for the Ethernet network card in order to allow them both to operate simultaneously. Updated RAS drivers from Service Pack 4 and disabling the Windows Internet Naming Service (WINS) provided the fix to these problems.

With the RAS problems solved and the Ethernet LAN cards configured to use TCP/IP, basic server connectivity was assured. Network performance utilities were used to provide baseline information as to the speed of the connections, and to flag any problems that may be present in the intranet-based network topology.

5.3.2.4 SIMnet Security

SIMnet security defines the baseline steps that NIST support personnel took in order to secure the client systems in the field, the SIMnet server, and any controllable networking infrastructure involved in the SIMnet system architecture.

The SIMnet client workstations were configured with a minimal set of security settings. The most important being user security. User security in the SIMnet system means creating separate user accounts on the SIMnet Windows NT Workstation computers. One account was used for the general user or metrologist to access applications, and another was used for the computer administrator to maintain the machine. By limiting the degree of administration privileges given to the normal SIMnet user, no inadvertent programs or Internet downloads can be installed that would jeopardize the SIMnet client machines integrity. Likewise, SIMnet client administrators were given full permission to maintain and administer the machine. By separating the two users into SIMnet users and administrator groups, a good deal of physical security can be maintained on the Windows NT system. The next level of client security occurs when the client systems must interact with the SIMnet server. Client authentication with the SIMnet server can be implemented to provide yet another layer of security protection.

Security concerns on the SIMnet server include: network access security, local machine logon security, web server access, and meeting room authentication. Network security involves securing any external communications infrastructure that falls under the responsibility of the NIST network control domain. Physical security with respect to the server and the network is accomplished by locating the server in a secure facility. Network security is maintained by positioning a firewall

between the system and the external Internet connection. Firewalls are an important security consideration for SIMnet in the future. Section 7 discusses the topic of firewalls and its impact on SIMnet.

Local machine logon security simply means that the administrators of SIMnet enforce good password choices (through minimum length requirements and other policy settings) during user manager account creation. Web access security involves the use of secure username and password mechanisms when administering the SIMnet server using the PictureTel NetConference Web Center. Web server security is further addressed in Section 7.

Finally, virtual meeting room security involves being able to secure a room on the server by using the PictureTel NetConference Administrator Console to either lock the room out or mark the room as being private. If the meeting rooms are marked as private, then the SIMnet client upon connecting to the meeting room must supply a password. This is an effective means of reducing the chance of malicious or inadvertent attempts to gain access to the meeting room. After we felt comfortable with the network performance, the client connectivity with the server, and the general configuration of the client machines, we initiated testing.

5.4 Testing

After the staging environment was fully configured and populated, site testing commenced. For the SIMnet system, the testing phase generally was concerned with the correct functioning and performance of all applications. For our purposes, newly configured client machines with only the required applications on the client-side were used. By using newly cloned machines, the chance of interjecting intractable side effects from errant device drivers or other components were reduced. Testing correct functionality of the client computers centered on optimizing the NetMeeting client to optimally use the PictureTel 330 software virtual meeting room settings. This required running innumerable test scenarios where the end-user would try various settings in NetMeeting and the server administrator would try optimizing the settings by changing the characteristics of the virtual meeting rooms parameters in the PictureTel 330 software. This process of tuning parameters, noting problems, and recreating the problems for feedback to the vendors took a considerable amount of time. EEEL application experts on an identical SIMnet computer performed extensive testing of the LabVIEW applications. Therefore, the SIMnet support personnel were not involved in this activity.

With regard to functional behavior, a number of straightforward tests helped to ensure that the applications and systems performed as expected. In addition to functional testing, preliminary performance tests were run before releasing the site. While the production environment posed unforeseeable challenges, a few simple tests were performed to uncover the most egregious bottlenecks. While performance testing is crucial for the SIMnet server site, which must support clients up to 700 times slower than an intranet, the intranet-based SIMnet server application also benefited from a thorough performance analysis. A poorly designed and configured SIMnet server application will increase the total load on the internal network.

The SIMnet server is intended to be accessed remotely using the Internet. Remote Internet connections to the SIMnet server via low-speed dial-up access lines would be used frequently to support the clients' activities in the field. Therefore, the internal modem and RAS services of Windows NT were used to dial-in to the SIMnet server and test the relative network performance of the dial-up connection and the execution speed of the NetMeeting client on that connection. By

setting up the dial-in connection to specific speeds, the limits of the conferencing session were determined. At a minimum, 28 kbps can support audio, limited video and data sharing capabilities. A 56 kbps connection is recommended to carry out reasonable SIMnet conferencing activities.

After the individual client applications, network connections, and PictureTel 330 server interactions were tested, all clients were then configured and connected to the PictureTel 330 conferencing server in sequence. The NetMeeting user interface graphically displays all the connected clients in the meeting. After all the participants in the meeting are connected, the audio, video, chat, whiteboard, and application sharing features in the conference are all tested. This process continues until all parameters in NetMeeting, the server, and the audio/video system have been set correctly.

As one can imagine, many different settings and application parameters can be configured during a SIMnet session. We characterized the optimal parameters for a variety of connection types, application uses, and video conferencing settings. We documented many of these and presented them to the OAS participants as part of the two-day training course prior to the SIMnet Inaugural. Upon the completion of the testing phase, the SIMnet team began to construct a support plan that would address client computer problems in the field. The next section discusses that plan in detail.

6 SIMnet Support

A comprehensive support plan is essential for successful SIMnet operations. A dedicated support team comprised of personnel with expertise in each of the core SIMnet technology areas is also a necessity. Members from EEEL, MEL and MEL's system administration group, or MELSA teamed to support SIMnet. The NIST support plan for the SIMnet project includes: training, technical support, and a means for capturing user feedback. A training course provided SIMnet users with a hands-on view of SIMnet. An extensive technical support plan provided for all contingencies throughout the SIMnet rollout. Feedback from SIMnet users to members of the support team was essential to track the root of any problems and to determine appropriate solutions. Each of these topics will be detailed in the following sections.

6.1 Training

Intensive training of both system administrators and metrologists on the SIMnet system was key to maintaining smooth operations. It is essential that there are system administrators at a site familiar with the software and hardware components. The availability of a SIMnet pilot system at NIST allowed for hands-on training of both users and administrators, and served as a platform to train new users and administrators from NIST.

Prior to the SIMnet Inaugural, NIST provided the training of metrologists and administrators by developing a two-day, hands-on SIMnet training course. The SIMnet pilot system at NIST was used as the classroom laboratory for this training. The training was well received by the participants and at the end of the training the participants became part of a highly visible SIMnet demonstration. The demonstration provided the participants with a chance to "use" the SIMnet technology in a functional environment. The design of the SIMnet training course is summarized in this section. For those interested in a detailed description of the topics covered, and as a template for those sites planning to set up their own training program, the complete training manual has been placed on the SIMnet Web site.

The training course consisted of two tracks. The first track was structured for SIMnet administrators and the second track for the SIMnet metrologists. A summary of the topics covered in each of the courses is presented in the following subsections. In addition to the in-house developed training materials, each training participant received a copy of the Microsoft NetMeeting Resource Kit manual. The NetMeeting Resource Kit manual is available (free) for downloading from the Microsoft corporate Web site²¹. In addition, the official Microsoft NetMeeting 2.1 book from Microsoft Press was provided to all participants²². This book provided additional insights into installing, using, and configuring NetMeeting that was outside the scope or time constraints of a two-day training session.

6.1.1 SIMnet Training for Administrators

The SIMnet administrators are the key technical personnel who would be responsible for the day-to-day maintenance and technical administration of the SIMnet client workstations once they were

²¹ The NetMeeting 2.1 Resource Kit version 2.1 and version 3.0 are available online at Microsoft at: <http://www.microsoft.com/netmeeting>.

²² The Official Microsoft NetMeeting Book 2.1 is available from Microsoft Press, ISBN: 1572318163.

deployed in the field. The training session for the SIMnet administrators focused on three important areas. The key technical areas that the training provided for the SIMnet administrators included:

- **SIMnet Hardware Overview and Configuration:** This session provided the administrators with an overall view of the SIMnet architecture and specific hardware peripherals that were used in the SIMnet client machines. Specifics about the client computers that would most likely need reconfiguration or maintenance in the field were discussed.
- **Windows NT Environment and Administration:** This session provided the administrators with a brief but thorough discussion of the important administrative functions of Windows NT and the SIMnet system software that would need to be configured and maintained. Areas for administration included the logon accounts and permissions, networking protocols, and modem communications.
- **SIMnet Software Overview and Configuration:** This session provided the administrators with an overview of all installed software on the SIMnet client computers. Configuration and maintenance of the software applications was also provided. The key software packages discussed included: Microsoft NetMeeting, Winnov Videum AV, pcAnywhere, National Instruments GPIB device drivers and configuration software, and the Norton AntiVirus software package.

The training manual developed at NIST provided a graphical representation of all the hardware that the SIMnet administrators would be responsible for maintaining. The hardware overview provided an itemized list of the SIMnet hardware products and capabilities of the client computers. In a parallel training session with the administrators, the OAS metrologists were also being trained. The next section discusses the training session outline that the metrologists participated in.

6.1.2 SIMnet Training for Metrologists

The SIMnet metrologists are the key technical members responsible for performing the metrology portion of the SIMnet international comparisons. Therefore, these members had to become familiar with how to use the application programs on the client systems in order to facilitate a SIMnet session.

The training session for the SIMnet metrologists focused on three important areas over the two-day training session at NIST. The key areas that the training provided for the SIMnet metrologists included:

- **SIMnet Digital MultiMeter (DMM)²³ Testing Procedures:** The SIMnet Web site includes procedures and best practices for testing the digital multimeters (DMM). This session provided metrologists with the training on how to use this information during a SIMnet international comparison. The location of the Web site on the Internet and the specific procedures were navigated with a browser and explained during this session.
- **GPIB Application Usage:** In support of the DMM testing, customized in-house EEEL-developed LabVIEW applications are used to verify a SIMnet international comparison. This part of the training session discussed where to obtain the applications on the Web and how to download, install, and use the applications in the DMM setting. Basic GPIB software

²³ Recall that digital multimeters (DMMs) are the devices used by the electrical measurement international comparison domain. The DMMs are very specific to the electrical measurement application domain and require device dependent testing procedures and training.

procedures to test whether the GPIB hardware was installed and functioning correctly were also discussed.

- **Microsoft NetMeeting Usage:** This part of the training session provided metrologists with an in-depth demonstration of how to use NetMeeting in the SIMnet-based DMM setting. After tutorials and demonstrations were performed, the participants were given hands-on training to reinforce the tutorial sessions. Because NetMeeting configuration parameters were standardized in SIMnet, we wanted to make sure everyone received an opportunity to participate in the process of viewing, changing, and resetting the options in a hands-on venue. The hands-on session was highly successful as many of the metrologists had previous experience with using NetMeeting.

6.2 Technical Support

After the SIMnet client computers are deployed to the field, many problems as well as normal upgrades and maintenance issues can occur. This is why a solid technical support plan is required to rectify any problems in the field. The technical support plan for the SIMnet client systems includes hardware support, software support, upgrades, monitoring end-to-end network performance, computer performance monitoring, and promoting self-maintenance through information dissemination. The approach taken for SIMnet technical support is detailed in the following subsections.

6.2.1 Hardware Support

The SIMnet hardware support was partitioned into two categories dependent on the severity of the problem, including catastrophic failure and minor hardware problems. A catastrophic failure is one where the client machine suffers major irreversible damage such as the machine getting destroyed during shipment, electrical mishaps, etc. In these conditions, MELSA has prepared spare machines that would be shipped overnight to the site. The problematic computer would be sent back to NIST. Fortunately, this phase of the support plan has not yet been exercised.

Minor problems associated with peripherals, internal hardware cards, or the system unit can be remedied in one of two ways. The hardware can be sent back to NIST for replacement or an onsite service contract call can be placed with DELL's local support group in the client country. A major consideration in choosing the DELL systems for SIMnet was DELL's ability to provide international contract service and support. Support in the field is an important consideration when rolling out systems to a wide geographic area. Just as with catastrophic failures, there have been no reports of minor problems with any associated components of the client computers.

6.2.2 Software Support

Installation of a number of software updates is expected to be required with SIMnet as the system matures. There will be system software updates and a variety of application updates. Any system changes must be made in a controlled manner which involves testing using an agreed upon rollout procedure. In the following subsections we detail the methods in place for supporting the software in the SIMnet system.

6.2.2.1 Metrology Application Updates

The metrology application updates are available to users from the SIMnet Web site maintained by EEEL. A SIMnet user downloads the most recent versions of the LabVIEW applications from the EEEL Web Site²⁴. New applications or upgrades to applications are tested on the NIST SIMnet testbed prior to release. In addition, a limited test is usually run among a small number of sites prior to a major collaboration involving a new software virtual tool. Because the DMM devices under test change frequently, the application programs used during the electrical international comparisons must be updated on a regular basis. For this reason, SIM metrologists must check the SIMnet Web site just prior to a scheduled international comparison for new verification software updates corresponding to the current device under test.

6.2.2.2 SIMnet Software Updates

Much of the SIMnet software, such as the Microsoft NetMeeting application, audio and video device drivers, the Windows NT operating system, and other related elements, require that updates occur on a regular basis. This fact is inevitable and must be accounted for in the support and maintenance plan of the SIMnet client workstations. As Service Packs are issued, updated versions released, and as key hot fixes appear, we are required to apply the upgrades in a controlled manner²⁵. In order to provide an updating service, the SIMnet development team created a service based on CD-ROM dissemination. The SIMnet development team used the Norton Ghost application to clone the hard disk image of a standardized and fully configured SIMnet workstation. Once this procedure was completed, CD-ROM's were created from this image, allowing for rapid distribution of client system updates.

The CD-ROM update distribution disk contained all required software upgrades. This eliminated administrators from having to locate specific Web sites and download (possibly very large) files. This would not only be inconvenient to the client administrators but might also allow the workstations to become "out-of-sync" with the basic standardized reference platform that we have specified for the trial. All upgrades on the CD-ROM were tested in the SIMnet testbed prior to client installation and rollout.

The CD-ROM means of dissemination is particularly useful for larger sites with multiple workstations as it ensures that changes to one machine will be propagated throughout the production environment. The CD-ROM based service was significant because the possibility of each workstation using a different version or update could jeopardize the successful connection, use, or deployment of the SIMnet client system. Therefore the CD-ROM update rollout was not only provided for an ease-of-use support feature for the administrators, but also to ensure that each client workstation was kept up to conforming specifications for connecting to the SIMnet server. Schedules for applying the updates are made available to all sites from the SIMnet Web site.

Another important ease-of-use feature was initiated by making the CD-ROM disks bootable. Bootable CD-ROM disks allow easy access and installation of various software updates. NIST support personnel created a CD-ROM complete with the Windows NT operating system, device drivers, and SIMnet related software on a single bootable disk that was shipped to each participant.

²⁴ The SIMnet Web Site maintained by EEEL is at: <http://www.eeel.nist.gov/SIMNET-DMM>. This URL is case sensitive.

²⁵ Service Packs are the traditional name given by Microsoft for a method to update various software products such as Windows NT. We use the term to include Windows NT updates as well as SIMnet related updates to application files and device drivers.

Providing bootable system CDs for updating the SIMnet workstations was a considerable time-saver and is a recommended practice for administrators required to deploy more than five identical workstations. The major difference with the system CD and the maintenance and support CD was that the system CD could provide a full system recovery automatically. If any catastrophic condition should occur to any system upon receipt (i.e., crash, virus, etc), then the administrator of the client workstation would simply place the CD into the system and reboot. The system would automatically reload the entire operating system files, device drivers, and SIMnet related application files. The system would then simply need minor configuration by the local administrator.

For incremental updates, a complete CD would be created that would again support a bootable scenario with the latest snapshot of the new complete system. This would free the administrator from applying too many patches over a long period of time between updates. If an incremental update was required, then the administrator could simply apply the new update to the system and forget about prior patches. This technique is similar to how Microsoft provides service pack updates. When a service pack is applied to Windows NT, it includes all prior updates to the operating system files. By applying the one service pack, you have effectively applied all incremental service packs from the beginning to the current release.

6.2.3 Identifying Client Bandwidth Constraints

A wide range of bandwidth capabilities is present among SIMnet sites. In addition, the Internet is not a static environment. The bandwidth available to a site can fluctuate a great deal, particularly for some sites. As the SIMnet client applications rely on the Internet for their successful deployment, end-to-end testing of the client bandwidth is essential for efficient operation.

The PictureTel 330 multipoint server software comes with a set of utilities to help determine if the end-user site will have enough bandwidth to support audio and videoconferencing over the Internet. One useful application in particular is called *NetTach*. NetTach, shown in Figure 21 is a network tachometer that can determine if the client's end site can support a videoconferencing session.

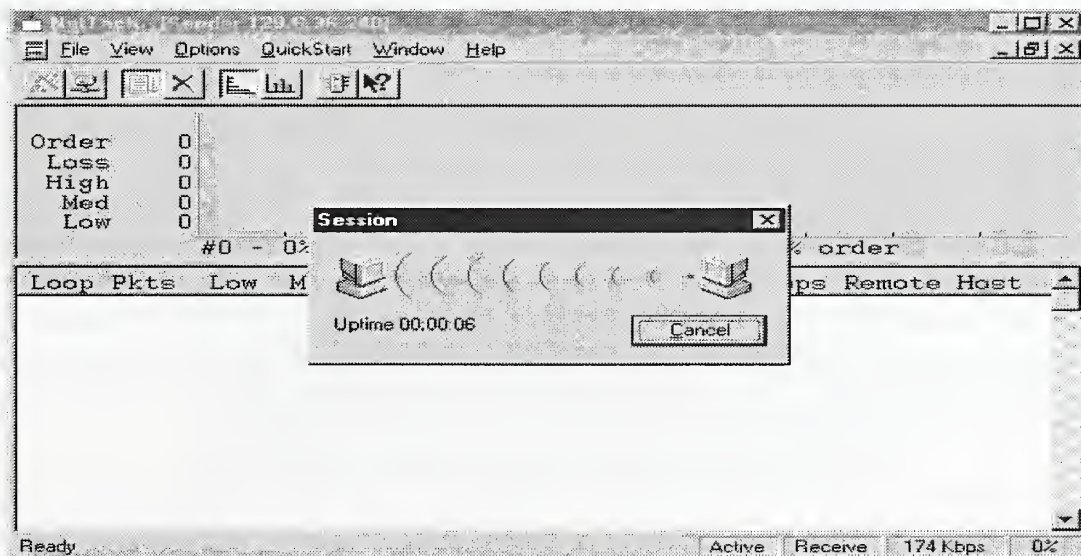


Figure 21: NetTach is used to determine available bandwidth for videoconferencing.

The NetTach tool can visually provide clues to the minimum bandwidth capabilities (audio, video, or application sharing) a SIMnet site can support. An end-user site can determine to what degree they will be able to participate in the conference (i.e., the user may only be able to use the audio and application sharing features of NetMeeting). This is very useful for limited bandwidth participants. Rather than having to attempt a connection that will prove to be unsuccessful, they can determine the proper settings beforehand. This tool helps support personnel address the requirement of dealing with a variety of bandwidth conditions – although we cannot increase a site's bandwidth, the site can still participate in a session given specific limitations determined by their connection speed.

NetTach is an end-to-end computer-to-computer tool that tests the TCP/IP connection between two stations and determines if they are capable of supporting H.323 conferencing. The NetTach system is set up in a client-server role where one end system acts as a server and the other site connects to it as a client and transmits information. A copy of the NetTach application is required on both the client being tested and a remote system. The remote system (the SIMnet client system in the field) will act as the server. The other system (located at NIST) acts as the NetTach client and connects to the remote NetTach server in the field.

A simulation of videoconferencing traffic between the two systems over the Internet commences by sizing and transmitting data packets with a frequency that approximates the traffic generated by a NetMeeting conference. The NetTach application then compiles statistics on the connection and graphically depicts the network conditions of the end-to-end connection. The answers NetTach provides will give a good indication of whether or not full audio and videoconferencing can proceed. In addition, the user will also be informed if participation can occur using a more limited subset of capabilities, perhaps only audio with application sharing.

The recommended procedure is for a site to check available bandwidth prior to the start of a SIMnet international comparison. In our testing, we have seen client sites that become either more or less responsive to bandwidth fluctuations over time. This occurs when Internet usage in one particular area becomes heavy or “bursty” but not significantly enough to degrade the overall performance of the client connection. In order to be prepared for these kinds of changes, it is important to monitor network performance and respond appropriately when it shows signs of deterioration.

6.2.4 Performance Monitoring

Sufficient network bandwidth is arguably the most important factor for successfully implementing an Internet-based videoconferencing system. However, if a client system attaches to the conferencing server with inadequate processor, memory, or disk drive hardware, then the conference will equally suffer as a result. Moreover, if the client has the required hardware, but it has not been configured or tuned correctly, then the client system can cause catastrophic damage to the conference. This is why it is important to monitor the system configuration and performance of the SIMnet server and client systems in the field.

The SIMnet server and client systems use Windows NT Server and Windows NT Workstation operating systems, respectively. Several Windows NT-based tools are available to monitor system-level performance and hardware configuration of the SIMnet computers. This section briefly describes these tools and how they can be used to maintain adequate Windows NT system performance. Both systems come with a number of administrative tools that are valuable for

monitoring the performance of a client or server system. Monitoring a system over time can indicate whether upgrades to disk or memory subsystems for example are required.

Two useful tools for monitoring system anomalies or system-level performance in a Windows NT environment are the *Windows NT Diagnostics* and *Performance Monitor* applications. The Windows NT Diagnostics tool provides a complete view of all resources used in the system. The tool provides key configuration information on all aspects of the Windows NT system including: services, resources (memory, interrupts, input/output addresses, direct memory addresses (DMA), and devices in the system), environment, network, disk drives, and the video display.

The Windows NT Diagnostics tool will aid the SIMnet administrator in troubleshooting errors caused by hardware configuration problems. Because Windows NT is not completely plug-and-play compatible, most hardware problems result from NT choosing a resource location that is already in use. The Windows NT Diagnostics tool can help to reduce this likelihood by being able to first locate the resources in use and to allow the operator to manually choose different unused values during the system configuration.

Common problems resulting from interrupt conflicts, memory conflicts, and other hardware maladies in a Windows NT system can easily be remedied using this tool. The diagnostic tool as shown in Figure 22 has just finished probing each device in the system and reports its interrupt request addresses. Managing conflicting interrupts in a Windows NT environment is to be expected when adding a variety of hardware and software components from different vendors. The Windows NT Diagnostics tool helps to identify potential conflicts.

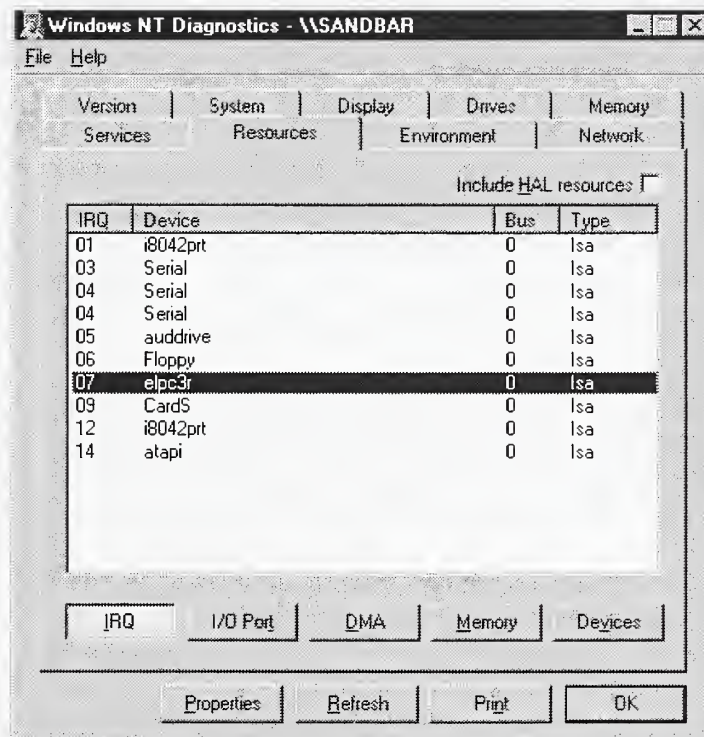


Figure 22: Using Windows NT Diagnostics Tool to resolve hardware conflicts.

Once the system is configured and running properly, it is beneficial to monitor the performance of the system. Monitoring the system performance of Windows NT can be useful when: (1) the

system response time slows or a process is compromising the CPU, or (2) the administrator must optimize the system cache by changing key Registry²⁶ settings, or (3) the disk drive is using inordinate amount of time when there is no apparent load on the system, and finally (4) a method is required to find out what the current virtual memory and paging statistics indicate. To monitor these types of activities in real-time, Windows NT provides an administrative tool called Performance Monitor. This tool, shown in Figure 23, provides a low-level environment to monitor all aspects of an executing Windows NT system.

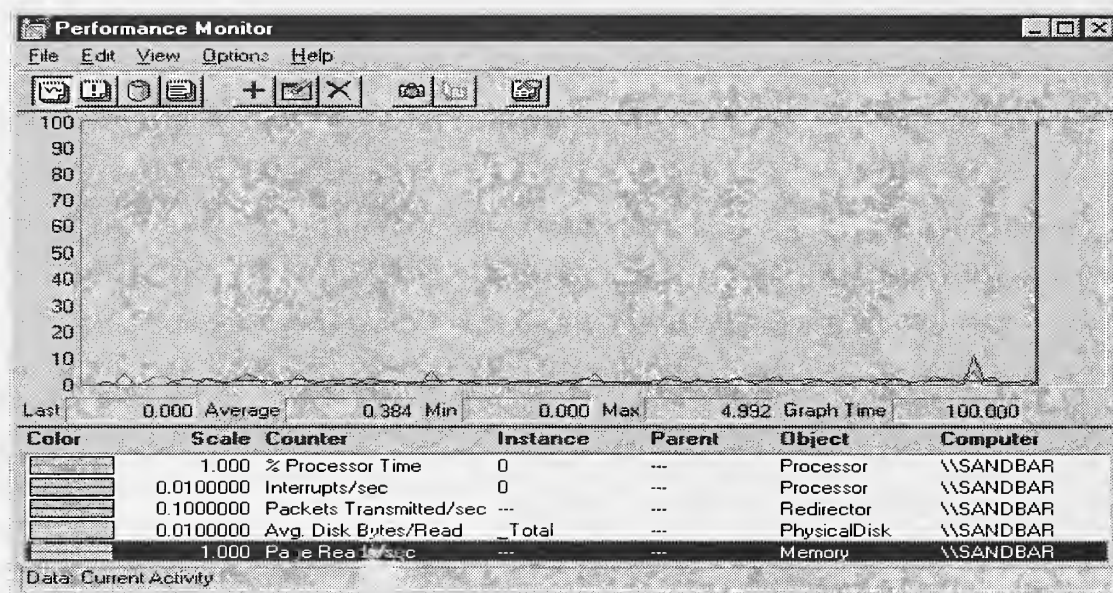


Figure 23: Using Performance Monitor to optimize the Windows NT environment.

Network throughput, real memory usage, virtual memory usage, physical hard disk reads and writes, and processor utilization can all be monitored using the Performance Monitor tool. The Performance Monitor relies on instrumented probes that have been strategically placed in the system software to monitor critical activities in the Windows NT Executive (kernel) and various subsystems. Performance Monitor activates these probes, thereby allowing the administrator to pinpoint the cause of system problems.

Additional information on these tools is available in the Windows NT documentation set. SIMnet administrators are encouraged to monitor performance of their systems on a regular basis (perhaps when connected in unofficial, ad hoc, or testing sessions with the SIMnet server) and in particular to use the tools on systems that experience noticeable performance problems. Additional useful tools and documentation are available to the interested reader from Microsoft and include the Microsoft BackOffice Server Resource Kit, the Microsoft Windows NT Server Resource Kit and supplements, and the Microsoft Networking Resource Kit.

Performance monitoring of network entities may also take place with server management techniques using the simple network management protocol (SNMP). SNMP provides an administrator with the capability to manage and detect problems with the server on the network from a remote location. SNMP is the standard protocol used for managing devices on the Internet. SNMP requires a database of information that relays device specific information using standardized

²⁶ From the Windows NT Help Glossary: "The Windows NT registry is a database repository for information about a computer's configuration. It is organized in a hierarchical structure, and is comprised of subtrees and their keys, hives, and value entries."

request protocols. The device specific information is stored in a database called a management information base (MIB). As long as the monitored device contains a device specific MIB, then the device (in this case the PictureTel 330 server) can be managed remotely from a graphical user interface tool. The PictureTel 330 server has been tested with Hewlett-Packard's OpenView. Currently, the SIMnet server has SNMP support but is not actively being managed by an SNMP manager. SNMP becomes convenient when several clusters of servers have been deployed. The maintenance, monitoring, and performance aspects of the servers then becomes more complex, requiring a more comprehensive plan including SNMP management support.

6.3 Information Dissemination

Technical support can be provided in many ways. An important part of the overall SIMnet technical support plan includes provisions for disseminating information about SIMnet to the user community. In addition, this part of the plan provides methods for gathering, documenting, and responding to SIMnet related user feedback.

SIMnet was a research prototype, with a small number of technical support personnel. Because the support team was small, we focused on developing information portals that delivered the greatest amount of information for the smallest support overhead. Therefore, user feedback and information dissemination channels were limited to Internet-based mechanisms including:

- SIMnet Web Site
- General SIMnet Email Address
- SIMnet Frequently Asked Questions (FAQ)

The information-based technical support plan provides a level of user support that reflects the limited size of the support team. For problems outside the scope of the plan, the support team refers the user to other sources of information such as manuals, Web sites, or product manufacturers. To resolve more difficult problems, we created a centralized point of problem resolution—this resolution point involved several people who were familiar with the configuration and rollout of the SIMnet system.

Mechanisms for providing information services became increasingly important due to the geographical diversity of the SIMnet client locations. Therefore, we established streamlined mechanisms for supporting user requests, feedback, and information distribution. The next several subsections discuss in detail the various Internet-based information dissemination techniques as well as the user feedback mechanisms that were put into place to support SIMnet users in the field.

6.3.1 SIMnet Web Site

At scheduled times, SIMnet participants were required to stay informed about special topics relating to SIMnet. Providing information and feedback mechanisms using the Internet was the key means of information dissemination to the geographically diverse SIMnet community. This site has been referenced throughout this document and continues to be the central repository for all information concerning SIMnet technical topics.

The EEEL-supported SIMnet Web Site provides the basic procedures for using the SIMnet system, scheduling of international comparisons, downloadable LabVIEW applications, and more. The top

level Web page of the SIMnet site is shown in Figure 24. This site provides an information service to the SIMnet user community as well as an additional collaboration tool.

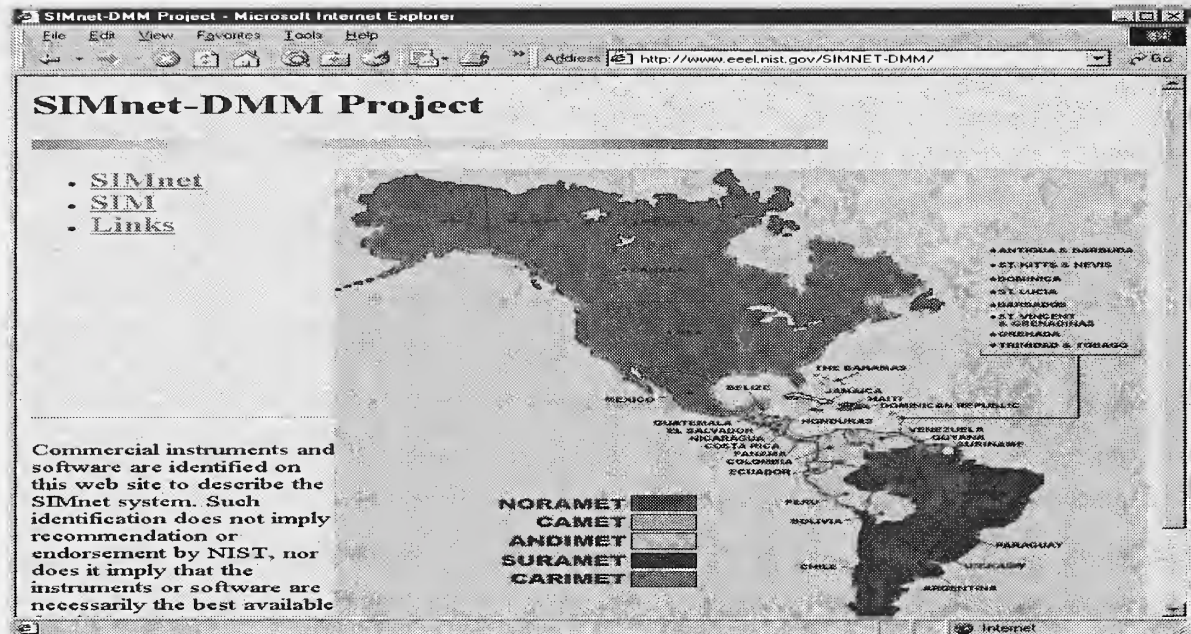


Figure 24: The NIST SIMnet Web Site provided by EEEL.

It is expected that as the system usage expands and the SIMnet client base widens, the centralized SIMnet Web site will be expanded to also capture user feedback. Integrating a database with the Web approach helps to organize and group common issues together for maximum resolution efficiency. Organizations considering a support system similar to that used in SIMnet are encouraged to provide such a service for users and administrators. The information should be complete and up-to-date. Other information dissemination mechanisms include a general email address for support and a FAQ for ongoing problem resolution.

6.3.2 Email Support

Due to the infrequency of user feedback (a great deal of feedback prior to deployment into the public user community was received via NIST internal trials), there was no driving need to provide an elaborate incident tracking database or other support repository. It was decided that a simple centralized email list (i.e., SIMnet@nist.gov) was sufficient for the trial period.

6.3.3 Frequently Asked Questions (FAQ)

A frequently asked questions, or FAQ format is ideal for addressing a variety of questions. Such a site provides new users with a means of coming up to speed quickly, a resource for administrators to find answers to questions and a location to post questions that may be of interest to others in the SIMnet community. A frequently asked questions list is currently being developed and will be placed on the SIMnet Web site as questions arise or important issues require generic answers. The FAQ provides a quick lookup area for issues that normally arise during initial use, installation, or re-configuration of SIMnet client application subsystems such as device drivers, operating system updates, or during a Microsoft NetMeeting upgrade. Another common element found on a FAQ is

a section that contains other URL links to Web sites that provide additional information on the concepts, products, or services related to the SIMnet system.

The key to successfully supporting the streamlined technical support activities was good communication between users and the support team. The users of the SIMnet system were briefed about the available options for support during the two-day training session prior to system deployment. Adequate training with hands-on sessions during the initial system deployment phase was instrumental in providing a solid and fundamental starting point for positive user technical support interaction during the initial system rollout.

6.3.4 Lessons Learned from User Feedback

The NIST SIMnet support plan provides a strategy to analyze the feedback from the users and a mechanism for the changes to be incorporated into the application. Without this necessary step, the SIMnet system cannot evolve into a better application over time. A great deal of feedback has already been gathered and included in SIMnet documentation such as a training manual, Web site, and this document.

We were able to learn a great deal about the usability of the system by compiling information from user feedback. Many issues were resolved through tuning and re-configuration of SIMnet server parameters or by re-configuring application parameters on the client workstations (i.e., tuning NetMeeting, video camera, graphics display card, and modem hardware parameters). Many issues are still outstanding due to the realities of bandwidth on the Internet, current state-of-the-art with H.323 standardization, and a lack of field site user training opportunities.

We actively looked for problems that were reported by multiple sites as a means of identifying inadequacies in the application or design. Fortunately, this did not occur and indeed, other than initial configuration problems with the Winnov software and hardware components, the systems remain stable. Although the audio and video subsystems from Winnov were of high quality, they were problematic during configuration because of the large number of possible configuration parameters. Once the proper settings were found and tested, all client machines were rolled out with these particular settings²⁷.

In the field however, values for the audio and video parameters can be changed, reeking havoc on the meeting if configuration options are not kept standardized. The server contends with many configuration anomalies by placing a common denominator on what standards and performance characteristics can be used during a meeting. Therefore, many of the problems associated with user configuration errors are resolved at the server by configuring the virtual conference rooms with certain minimal connection constraints.

Most operational problems that did occur were so varied or intractable that no conclusions could be drawn except to say that the dynamic nature of bandwidth availability on the Internet poses great challenges for SIMnet system designers. In fact, the current version (in addition to the currently testing version 3.01 software) of the Microsoft NetMeeting application on the client was found to provide an adequate level of functionality for bandwidth limited areas. Internet bandwidth is increasing rapidly in many areas of SIM. As bandwidth on the Internet eventually increases, so too will the rapid emergence of SIMnet-like systems to fully utilize this potential.

²⁷ In addition to a large number of parameters, during configuration, some settings would revert back to the default ones if special care were not taken to set ALL specific parameters prior to engaging the meeting.

7 Future Issues

There are a variety of standards initiatives emerging that will have an impact on future updates to the SIMnet system design and deployment plans. This section details several such initiatives and what they will mean for future SIMnet systems.

Changes in the ITU H.323 protocols will substantially impact how future SIMnet systems are deployed and connected over the Internet. A key H.323 protocol change will provide a more scalable approach for interconnecting SIMnet servers. This change affects how the multipoint control units (SIMnet servers) are interconnected to provide a more bandwidth friendly environment on the Internet. This change in the H.323 protocol emerged in version 2 of the protocol and is referred to as “cascading”. Cascading the MCUs will be discussed in greater detail in Section 7.1.

Another key area that is attracting a great deal of attention is security. Many security issues arise from the fact that the Internet is just beginning to be used as a serious electronic commerce platform. As the power, flexibility, and the reach of the Internet continues to expand, so too will the possibilities for illegal activities to exploit the information flowing across it.

Many security advancements and initiatives on the Internet were conceived as reactive measures. However, a more proactive stance on security technology innovation is occurring. As these more proactive advancements (i.e., per data stream hybrid forms of the public key encryption and infrastructure standards) to security on the Internet emerge, every effort will be made to incorporate them into the SIMnet infrastructure. A few proactive H.323 security initiatives are already being implemented in the next software release of the PictureTel 330 multipoint conferencing software, which is version 2.1. Security capabilities are discussed in Section 7.2. Section 7.3 concludes with a look at the issues concerning the next-generation rollout of SIMnet, or *SIMnet2*.

7.1 Cascading SIMnet Servers

The PictureTel 330 Conferencing Server software used in SIMnet is optimized for high bandwidth situations such as those found on an organization’s internal network, or Intranet and high-speed remote access situations (i.e., 56 kbps or greater). When the SIMnet server is accessed over long-haul Internet trunks or from low-speed remote dial-in users, then considerable bandwidth constraints are placed on the SIMnet system. These constraints are due mainly to non-localization of Internet connections between the SIM metrology centers in the field and the SIMnet server hosting facility at NIST.

In recent NORAMET trials, it has been shown that using SIMnet within a single SIM metrology center has resulted in good performance with acceptable collaboration. Many of the problems associated with holding widespread inter-center meetings (i.e., between NORAMET, SURAMET, and CARIMET for example) have been attributed to large differences in Internet speed, computer configuration errors, or non-standardized computers. Moreover, the critical area that severely degrades performance during inter-center meetings results from providing and maintaining many long-distance Internet connections between the NIST site and the various metrology centers throughout the Americas. Figure 25 illustrates this problem by showing how the current SIMnet system uses individual TCP/IP-based unicast Internet connections for each inter-center connection. This type of unicast TCP/IP connectivity results in a one-to-one mapping between connected

participants in the conference and open connections across the Internet to the host facility, in this case NIST.

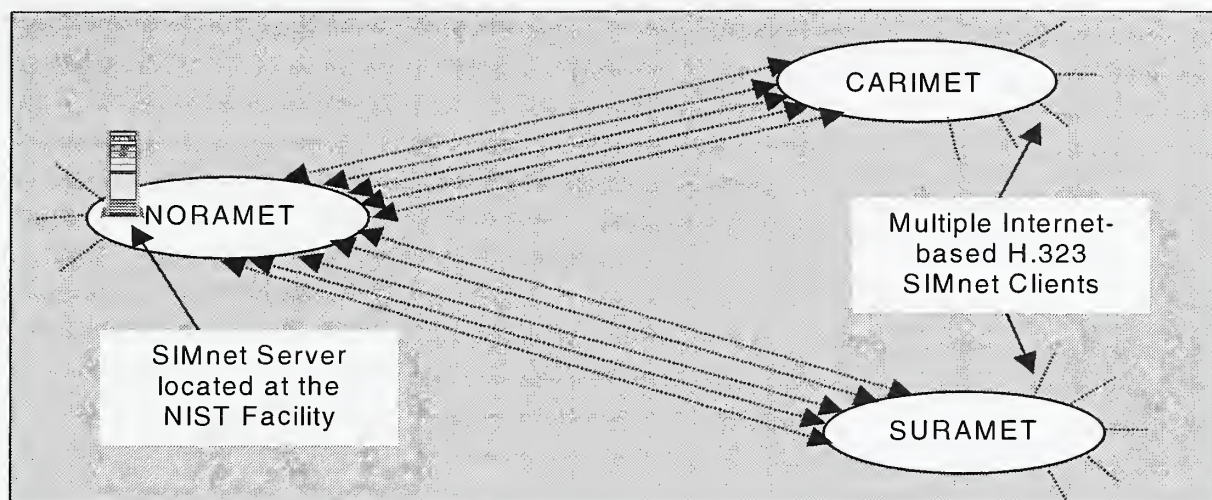


Figure 25: The centralized SIMnet server hosts multiple Internet connections.

When NIST hosts the meeting, and NORAMET, CARIMET, and SURAMET are involved for example; all the participants must first connect with the NIST site. The NIST site acting as the host server for NORAMET provides all the services to the current meeting. Figure 25 shows that many connections (one TCP connection at a minimum for each participant) are needed to bring everyone online. If the connections are degraded or the user machine is not configured correctly, then the communication can suffer. These anomalies unfortunately may impact the performance of all participants' audio, video, and data sharing capabilities during a videoconferencing session.

The greatest negative impact to a SIMnet session occurs when a participant in the meeting with the most limited Internet speed connection is also the data generation source. For example, if a user in the SIMnet session shares an application from a laptop computer that is dialed into the SIMnet server at 33.6 kbps from the Internet, then all users will notice a delay in the SIMnet system response time. This happens because all users receive the data in approximately the same time that it takes for the server to receive and process the data from the participant's limited Internet connection. This results in a perception that the SIMnet session is running slow. When in fact, the network latency is impeding the server from receiving the data it needs to propagate to the others in the conference.

With severely degraded connections, the server may in fact disconnect the client because the minimum bandwidth requirement for the connection cannot be maintained. Unfortunately, if the disconnection phase does not occur gracefully, the server may have problems recovering and the session may need to be restarted. These connectivity issues are being addressed; however, this represents an example of the problems that can arise when using state-of-the-art videoconferencing technology on the Internet.

A reasonable solution to this problem would be to locate a SIMnet server within a designated member country for each SIM regional metrology center. This would also alleviate the NIST facility from being the centralized focal point for all connections at all times. During those types of meetings only a single regional center (intra-center meetings) would be involved (this is similar to the NORAMET trial), all access to the server would be made within the geographical region of the

specific metrology center. When inter-center meetings are required, for example, when NIST becomes the host country to many metrology centers as shown in Figure 25, then each member country would initially connect with their own respective centers' server as in the intra-center case. However, when communication between the centers occurs, then only one connection (one connection for each server) is needed instead of issuing multiple Internet connections to the NIST facility.

This idea scales well with current usage patterns of the SIMnet server. Typically, two users are participating in a SIMnet conference and actively generating traffic between the centers at any given time. All others are passively observing the conference from their respective centers; thereby, localizing the Internet traffic around each server. The idea of interconnecting SIMnet servers together is called "cascading". SIMnet could benefit from cascading because of the localized usage patterns exhibited during typical sessions. The concept of cascaded servers is illustrated in Figure 26. Cascading is an evolutionary approach to reducing the amount of Internet bandwidth required to support videoconferencing. The cascading feature was defined within the framework of the ITU H.323 multimedia protocol standards and is just starting to emerge in videoconferencing server-based products.

When servers are cascaded together, one Internet connection between each SIMnet server at each region is required. A key infrastructure difference is that each metrology center maintains and controls an individual SIMnet server system. This provides the added benefit that each center can perform localized meetings without having to access the centralized NIST server over a long-distance carrier or slow dial-up link. Many centers have requested the capability of hosting localized meetings in this manner.

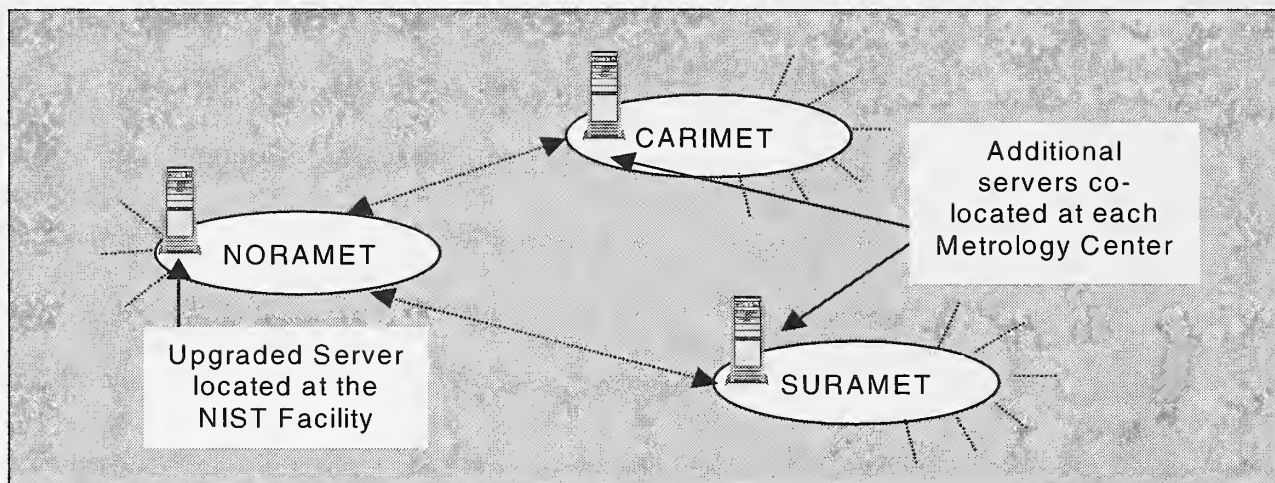


Figure 26: A cascaded design reduces overall traffic between servers by using one connection.

Using the cascaded design, when one center wishes to communicate with another center, the calling server is connected to the other server by calling into a virtual conference room on the remote server. This way, the Internet traffic for a particular center stays localized with the server of the local metrology center it is serving. The only long-distance Internet traffic required will be one single connection between connected servers. In each metrology center, the subregion that can support the highest available bandwidth for Internet connections to the other centers should host the server. This would expedite any long-distance Internet traffic over the single connection. Therefore any failures at the local center should not affect the total system as it currently does today. In

addition, centers wishing to carry out their own meetings without connecting over multiple long-distance Internet links to the NIST facility can achieve this using the cascaded scenario.

In addition to reducing the overall bandwidth required, cascaded servers also provide a more scalable solution. For example, the current SIMnet server is limited to supporting 24 connections. Eventually, more than 24 people will need to connect to this system. How can we scale the server to support more than 24 users? Ruling out a broadcast or multicast solution for the present time, additional scalability can be met in the near-term by utilizing the cascaded approach. Using the SIMnet example shown in Figure 26, if one server supports 24 users and two other metrology centers connect together using the cascading feature of H.323, then you have effectively scaled the available meeting capacity to 72 users (3 cascaded servers x 24 ports/users). We are currently testing a 40-port version of the PictureTel 330 software. When available, this version cascaded as before could yield 120 total users (3 cascaded servers x 40 ports/users) on the SIMnet system.

A final factor to consider with cascaded videoconferencing is how the sites are networked together. Care must be taken to analyze the bandwidth between the sites in order to determine whether there is enough bandwidth to handle day-to-day data transfers in addition to the expected amount of videoconferencing traffic. If not, the amount of bandwidth on the wide-area network (WAN) link must be increased or higher-speed routers and switches that minimize jitter and packet latency must be used. There are router products that can prioritize H.323 traffic to deliver maximum audio and video performance. Look for these types of communications equipment when designing the network backbone.

In summary, in order to handle anticipated future growth of SIMnet, a series of interconnected, or "cascaded" servers, for each SIM metrology region or center should be deployed. Adding additional servers and upgrading them to the latest H.323-based software will provide the added scalability needed for resilience against large-scale Internet bandwidth degradation while also supporting more users in a scaleable manner.

7.2 Security

The Internet was originally conceived to be an open, flexible, and collaborative environment, and security implementations were not a primary concern. As the scope of Web applications has widened to include for example, transaction-oriented electronic commerce, a need to protect the data has increased. This subsection addresses two broad areas for ensuring the security of a site: user access control and data protection.

In terms of these two areas, security in the SIMnet system will need to be addressed from the administration, usage, and deployment aspects of the system. Security aspects in any future SIMnet system will need to be defined in four areas: (1) emerging H.323 protocol security capabilities, (2) client-side application (i.e., Microsoft NetMeeting) and protocol advances in security, (3) generic Internet-based methods for access and authentication, and (4) built-in server-side administrative security capabilities.

In version 3 of the newest ITU H.323 draft standard, inherent security mechanisms are currently being defined. Many of these standards for security are being incorporated into the latest releases of the PictureTel 330 Multipoint Conferencing Server software.

7.2.1 Inherent H.323 Security

Realizing a need for a more secure videoconferencing environment, the ITU H.323 committee has started working on a security initiative called H.235 (H.235 has been termed *H.Secure*). The H.235 initiative will provide privacy through the use of encryption mechanisms. Privacy and encryption mechanisms on packet networks such as the Internet have recently become a major concern. H.235 also will provide authentication features. Where many authentication schemes for users and applications have been discussed in this document, they all represent external methods for providing security. H.235 proposes an integrated solution to the encryption and authentication problem within the H umbrella standard protocol framework.

Public and private key infrastructure security initiatives such as RSA²⁸ and the Digital Signature Standard (DSS)²⁹ are being included in the H.235 initiative. Encryption of individual media streams will also be supported. This is a hybrid approach that will provide a way of encrypting important information on a per stream basis while not imposing high security processing overhead on all streams of audio, video, or T.120 protocol data. Finally, signaling security aspects are being addressed to prevent the “spoofing” of connections or attempts to redirect communication endpoints. All of these initiatives will inherently be found in the H.235 portion of the H.323 umbrella recommendations. As these enhanced security features emerge in new H.323-based versions of the MCU-based servers and clients, they will be incorporated into the SIMnet architecture.

7.2.2 SIMnet Client Application Security

Microsoft NetMeeting is currently the SIMnet client application commonly used to connect, view, and interact with other participants during a SIMnet conference. As security advances with Microsoft NetMeeting (including all H.323 based client applications) continue, these advances will be integrated into the SIMnet architecture as part of any NetMeeting upgrade procedure. For example, the next announced version of Microsoft NetMeeting is a major release and has just been released to the public. This is called Microsoft Windows NetMeeting 3.01. With this new release, Microsoft has implemented security aspects of videoconferencing that include data encryption capabilities in all facilities of NetMeeting. In addition, user authentication and password protection in NetMeeting for meetings has also been strengthened. The following areas in NetMeeting have been addressed in the new version with respect to data encryption security initiatives:

- Encode the data exchanged between shared programs, transferred files, Chat, and Whiteboard.
- Specify whether all secure calls are encrypted.
- Hold secure conferences where all data is encrypted (audio and video are disabled).

User authentication has also been addressed in the newest version of NetMeeting 3.01. The following user authentication issues have been resolved in the new version:

- Verify the identity of participants by requiring authentication certificates.
- Require a NetMeeting certificate (automatically generated during NetMeeting setup).

²⁸ RSA is named after the inventor's surnames' first letters: Rivest, Shamir and Adleman. For more information, check out <http://www.rsa.com/index.html>.

²⁹ DSS is the security standard developed jointly by NIST and the National Security Agency (NSA) that incorporate the Secure Hash Algorithm (SHA-1). The DSS fact sheet is available at http://www.nist.gov/public_affairs/releases/digsigst.htm.

- Require a personal certificate issued by an external certifying authority or intranet certificate server.
- Schedule secure conferences that require all participants to have a certificate.

Finally, Microsoft added password protection to the list of available security features. With password protection in the new version of NetMeeting, you can:

- Host a meeting that requires a password.
- Use the Remote Desktop Sharing capability to control one computer from another or vice versa.

The SIMnet conferencing server used does not support the latest version of NetMeeting. A recommended practice with new releases of software is to put the release through a testing phase on a test machine prior to using it in a production environment. PictureTel currently supports many new features of NetMeeting 3.01, with full support planned by the end of the year. In order to support the new NetMeeting client, the server software will need to be updated. This updating procedure is planned, however it will not be implemented in the short-term. The version incompatibility issues are not currently problematic for SIMnet users as their client systems are using NetMeeting 2.11, which is fully compatible with the current PictureTel 330 server software version 1.0.1.

7.2.3 User Access Control

An Internet-enabled application such as SIMnet raises a number of user access concerns. If there are restrictions on who may access the application, what mechanism should be used to filter out the unwanted users? How does an organization control who may modify application content? This subsection examines two strategies for controlling user access: firewalls and client authentication.

7.2.3.1 Firewalls

Organizations configure and use firewalls to control Internet access to confidential or otherwise sensitive information on their Intranet. Because they are designed to exclude entire sets of users from entire servers, firewalls are more useful in some circumstances than in others. However, because this type of technology also constrains access to resources, the side effect is that legitimate users cannot use various resources either. This fact has become an unfortunate dilemma for information technology professionals as they struggle with ways to implement secure yet fully accessible systems on the Internet.

A system such as SIMnet that generates a variety of traffic from dynamic audio and video streams to static file transfer data will be severely impacted by the use of firewall configurations. It is hoped that eventually security issues and their firewall-based solutions will wane; opting for more integrated per Internet stream related security measures as can be seen in the newly emerging security initiatives in H.323. However, for now the SIMnet system must deal with the possible security implications of a firewall-based network configuration.

NIST connects to the Internet using a firewall to protect its private internal networks. However, the SIMnet server is currently located outside of the NIST firewall. This initially was done to minimize known configuration problems associated with newly implemented firewall strategies. Because only a limited and known set of people were testing the server, it was reasonable to locate the SIMnet server outside the firewall. Probably the most important and immediate reason for placing

the server outside the firewall was to eliminate any SIMnet client-side problems with respect to connecting to the server from behind a firewall. For the initial rollout of SIMnet, a major re-configuration of the SIMnet server, the firewall at NIST, and the client workstations would have caused a great deal of anguish for all involved. In many cases, some participants might not be able to connect or fully participate due to severe restrictions in the firewall configurations. A problematic start to the SIMnet rollout was clearly not what we wanted the users first impression of this system to be.

The network portion at NIST that is accessible from the SIMnet site however is in the process of being protected by a firewall. For the trial period of SIMnet, it is expected that the server portion of the SIMnet infrastructure will remain outside the firewall protected area on the NIST public network as shown in Figure 27.

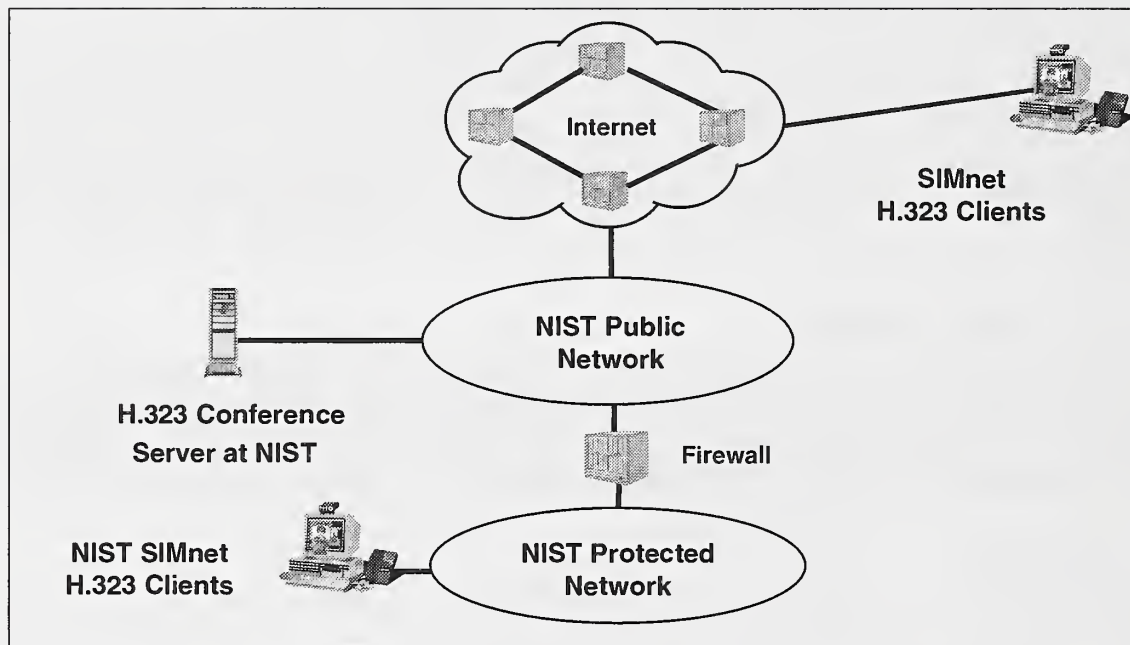


Figure 27: The location of the SIMnet server in relation to the NIST firewall.

Until such time when all issues with using NetMeeting through a firewall can be conveniently configured for maximum security, the SIMnet server will remain on the NIST public network as shown in Figure 27. For those OAS sites calling into the NIST SIMnet server that are not part of a firewall installation, no further firewall configuration is necessary. These sites freely allow the dynamic setup and teardown of various Internet Protocol ports required by NetMeeting. If your remote SIMnet client site is currently behind a firewall, then you will need to discuss how to make your firewall NetMeeting friendly with your network and firewall administrator. This subsection contains the information that firewall administrators will need to configure the firewall in order to make it possible for NetMeeting traffic to flow freely. This information is targeted at the technical aspects of firewall administration and therefore may not be of interest to the general reader.

7.2.3.1.1 Microsoft NetMeeting and Firewalls

If your organization currently uses NetMeeting through a firewall to call into the SIMnet server over the Internet, several Internet Protocol ports are required to establish the outbound connection. If you use a firewall to connect to the Internet, it must be configured so that the Internet Protocol-

based ports shown in Table 1 are not blocked. A thorough discussion of ports, TCP/IP, and their relationship with NetMeeting is beyond the scope of this document. For more information, the reader is advised to obtain the Microsoft NetMeeting Resource Kit 3.0 (see footnote 21, page 63).

Port	Description
389	Internet Locator Server (TCP)
522	User Location Service (TCP)
1503	T.120 (TCP)
1720	H.323 call setup (TCP)
1731	Audio call control (TCP)
Dynamic	H.323 call control (TCP)
Dynamic	H.323 streaming (RTP over UDP)

Table 1: Internet Protocol ports not to block when using NetMeeting through a Firewall.

To establish outbound NetMeeting connections through a firewall, the firewall must be configured to do the following:

- Pass through primary TCP connections on ports 389, 522, 1503, 1720, and 1731.
- Pass through secondary TCP and UDP connections on dynamically assigned ports (1024-65535).

The H.323 call setup protocol (over port 1720) dynamically negotiates a TCP port for use by the H.323 call control protocol. Also, both the audio call control protocol (over port 1731) and the H.323 call setup protocol (over port 1720) dynamically negotiate UDP ports for use by the H.323 streaming protocol, called the real time protocol (RTP). In NetMeeting, two UDP ports are created on each side of the firewall for audio and video streaming, for a total of four ports for inbound and outbound audio and video. These dynamically negotiated ports are selected arbitrarily from all ports that can be assigned dynamically.

NetMeeting directory services require either port 389 or port 522, depending on the type of server you are using. Internet Locator Servers (ILSs), which support the lightweight directory access protocol (LDAP) for NetMeeting, require port 389. The User Location Service (ULS), developed for NetMeeting 1.0, requires port 522.

The NIST SIMnet server will likely stay on an external public network maintained at NIST for some time until all NetMeeting issues with firewall connections can be understood or better approaches to security arise. Therefore, for the foreseeable future SIMnet users will not have to worry about any NetMeeting interactions with firewalls. However, as the security issues and threats to the networking and computing infrastructure at NIST increase, enforcement of basic authentication and admittance policies will be inevitable. Most of these policies will be in the form of client authentication with respect to the SIMnet server. The authentication techniques on the SIMnet server are discussed below.

7.2.3.2 Client Authentication

Sometimes it is beneficial to require a user or administrator to supply a username and password before accessing either all or a portion of the SIMnet site. When using the Web Center, IIS provides two authentication schemes: Basic and Windows NT Challenge/Response. Both approaches permit authentication on a page-by-page basis to permit different levels of security on a

single site. Of the two, NT Challenge/Response is the more intrinsically secure, since it automatically encrypts the password submitted by the user. It is, however, supported only by Internet Explorer 2.0 and later, so if other browsers must be supported, Basic authentication must be employed.

Client authentication using the NT Challenge/Response mechanism is recommended for administrators logging on to the IIS 4.0 based NetConference Web Center, Scheduler, or GateKeeper Web-based software, if installed³⁰. Because Basic authentication does not encrypt the data being sent over the network, it is advisable to employ an encryption mechanism such as the secure sockets layer (SSL) to protect the user's password. Windows NT Challenge/Response is particularly useful to restrict corporate Intranet access to current users. In this form of authentication, the name and password are used to verify permissions at the time of the user's computer logon. This account, including the domain, must be a valid account on the Windows NT Server that is running IIS for the user to be allowed access to protected pages.

Client authentication for users of SIMnet is important when clients are using specially marked private virtual rooms in the SIMnet conference. In this case, they will need to authenticate with the SIMnet server. Currently, the SIMnet server uses non-reserved public rooms for international comparison sessions. This means that all users who know the IP address and the room name on the SIMnet server may enter the meeting without being required to supply a username or password. This policy will undoubtedly change in the near future. When it does, the client authentication scheme will be SSL-based and similar in functionality to the administrator logon process (i.e., a username and password encrypted pair).

7.3 Continued Beta Testing

As part of the ongoing testing, upgrading, and maintenance aspects of SIMnet, NIST researchers have been participating in several beta test studies with PictureTel and other H.323 technology provider companies. These studies require a testing environment nearly identical to the current hardware configuration for the SIMnet server. The testing is part of a collaborative effort at NIST to work with H.323 vendors to discover the issues of deploying these types of systems across the Internet using limited bandwidth situations. In addition, by beta testing new conferencing server software, NIST provides a great deal of feedback to PictureTel about issues and problems that naturally come up during any beta release period. This feedback helps PictureTel to target areas where improvement, speed, or ease of use issues can be better addressed with any follow-on product offerings. This relationship has been mutually beneficial in solving issues related to software efficiency and bandwidth utilization.

NIST recently completed a beta test of the latest PictureTel 330 v2.0.1 product. The system utilizes several new features of the H.323 protocol including "cascading" and several of the new security measures previously discussed. These are exciting new features that should provide a great deal more flexibility in upgraded SIMnet servers as security and scalability become more pressing concerns to the international community.

Large client-server systems like SIMnet generally benefit from beta test periods in which a select group of users are asked to use the beta system and to provide feedback on its virtues and shortcomings. To gain maximum benefit from a beta test period, it is important to obtain a

³⁰ PictureTel NetConference GateKeeper software is not currently in use in the SIMnet system. GateKeeper software provides a software layer for administratively controlling bandwidth, access and admission policies, and performance criteria for a cluster of SIMnet servers.

representative sampling of users. For a publicly accessible Internet application such as SIMnet, this means assembling appropriate users with varying degrees of experience with both the Internet and the metrology-based subject matter.

As part of the formal beta testing process with PictureTel, NIST researchers provide detailed feedback response forms that contain questions about the application's performance, functionality, features and overall design. This input can be applied to both the current and future versions of the application. This input provides the PictureTel 330 development team with valuable information to make the application as stable and usable as it can be before it is released to the general public.

In addition to testing PictureTel products, NIST is currently engaged in testing other H.323 compliant products as they emerge into the marketplace. Products implementing H.323 MCU's and client applications are currently being researched for suitability with the SIMnet system. As these products and the H.323 standards solidify, they will be incorporated into current and future SIMnet system designs.

7.4 H.323 Client Application Updates

The use of Microsoft NetMeeting in the SIMnet system is instrumental for providing a low-cost H.323 client to the 11 SIM member nations and eventually all 34. Therefore, it is important that the NIST SIMnet architects closely monitor the progress Microsoft makes in providing updated versions of the NetMeeting application.

SIMnet is currently using version 2.11 of Microsoft NetMeeting. Figure 28 shows the user interface of NetMeeting 2.11 as it is being used during a SIMnet testing session.

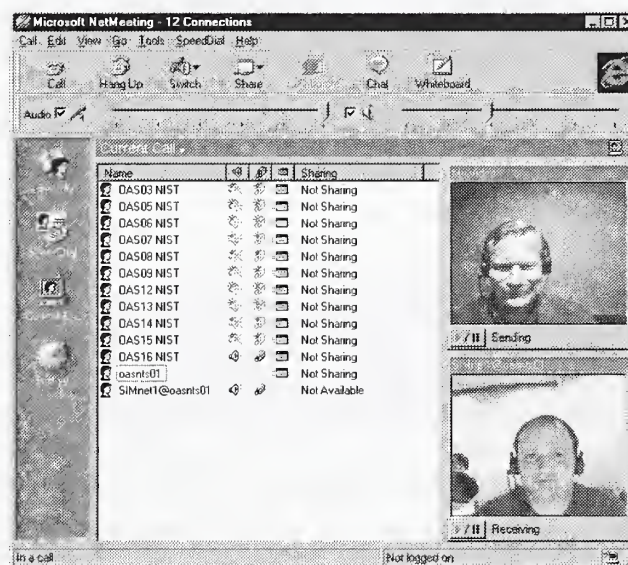


Figure 28: Microsoft NetMeeting version 2.11 is currently used in the SIMnet system.

As with any successful software product, newer versions are released that fix problems and add functionality to the application. With any new arrival of software comes the unforgiving chore of upgrading, installing, supporting, and training users on a particular software product. Microsoft NetMeeting is no exception to this rule. The SIMnet support team has measures in place to introduce upgrades without disrupting current operations. We do extensive prior testing and have a simple yet effective software rollout mechanism in place.

As this document goes to press, Microsoft has made several important announcements concerning the future of the NetMeeting product, and in fact has provided an update to the NetMeeting application that changes the NetMeeting look and feel, execution, and implementation of newer portions of the H.323 standard. Figure 29 illustrates a screen image of the latest Microsoft NetMeeting version 3.01.

Microsoft has announced that the NetMeeting application will have a different name. The new name is Microsoft Windows NetMeeting, to indicate that it is now an integral part of the Windows family of products. The availability of NetMeeting will be greater as it will now be bundled with all Windows-based operating systems. Originally, NetMeeting was effectively just another Microsoft add-on application, available through the Microsoft Web site or through a full installation of Internet Explorer. This move by Microsoft increases the availability by officially supporting it as a bundled product of Windows.

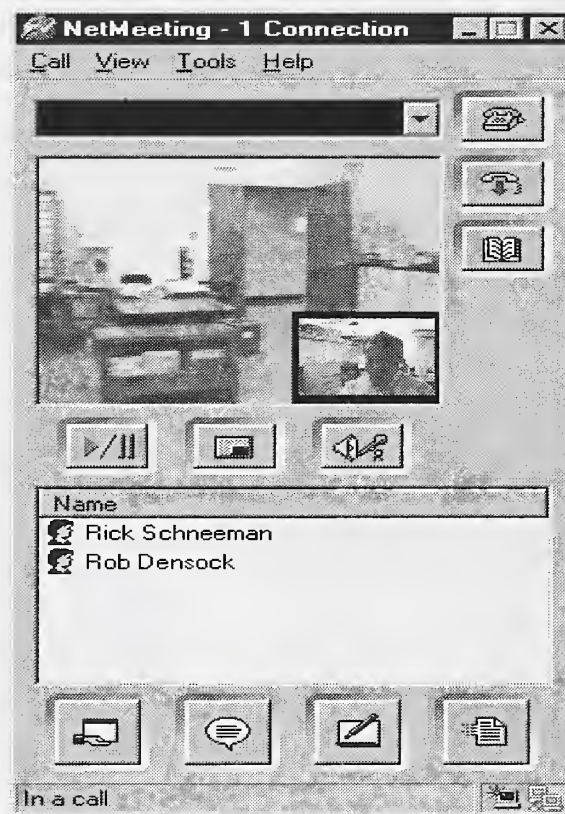


Figure 29: The new user interface of Microsoft Windows NetMeeting™ 3.01.

As can be seen in Figure 29, the user interface of NetMeeting 3.01 has changed substantially. NetMeeting 3.01 is now more compact and centralized with push-buttons location on the front-panel representing all the functional aspects of the old NetMeeting. Preliminary beta testing with the product shows an increase in performance with respect to the audio and video compression technology. Security has also been implemented more rigorously in this version as well.

An interesting new feature in NetMeeting 3.01 is its use of the remote desktop protocol (RDP). RDP is a variant of the T.120 protocol for data and application sharing called T.128 and is also part of the H.323 recommendation. Microsoft and PictureTel co-developed portions of the T.128

protocol³¹. RDP allows a remote desktop to be shared just as the pcAnywhere software provides the remote control and administration feature. This feature could be used later to supplant the pcAnywhere client application.

Current interoperability trials between beta versions of the PictureTel MCU and NetMeeting 3.01 have revealed several issues. Connection problems associated with H.323 implementation differences do not allow the new NetMeeting version to successfully connect to the latest version of the PictureTel server. As part of the beta testing feedback program with PictureTel, NIST has learned that the connectivity and interoperability issues with NetMeeting 3.01 and the PictureTel MCU have been for the most part resolved. A software update in the form of a “patch” will bring the latest server version to 2.0.1. NIST beta testing will continue with the patched version 2.0.1 and use the latest available version of NetMeeting for continued SIMnet testing. It is expected that the next major software update to the current SIMnet system will use both the updated PictureTel 330 version 2.1 or higher and Microsoft NetMeeting 3.01 or higher when released.

7.5 The Next Step: Toward Implementing SIMnet2

The SIMnet pilot system has received a considerable amount of positive feedback during its initial trial. As a result, several requirements to further enhance the system are being defined including: (1) to increase the number of users capable of connecting to SIMnet, (2) strengthen the security of the system, and finally (3) implement key features to increase the usability of the server software. An enhanced system based on these modifications is being defined as *SIMnet2*. SIMnet2 would support these enhancements by incorporating recent advances in the H.323 protocol implementation of the PictureTel 330 server software. These advances include the use of cascaded servers, H.235 security techniques, and optional features found in the updated H.323 protocol recommendations.

The first enhancement planned for SIMnet2 targets bandwidth constraints of the Internet and provides a more scalable approach to interconnecting the remaining 23 SIM metrology centers. By increasing the number of available client sites, SIMnet2 would be able to connect all 34 regions of the OAS. Initially, the SIMnet2 rollout for all 34 sites would be implemented using an upgraded version of the PictureTel 330 server software. The upgraded version is capable of supporting up to 40 users; therefore the server theoretically could support all 34 OAS member sites. In practice however, the required amount of localized bandwidth needed at a single server to support all 34 Internet connections would not be available at all times.

The amount of bandwidth required for all 34 audio, video, and application-sharing sessions using a non-cascaded design would be significant. This fact predicates that a new design that significantly reduces the overall Internet bandwidth requirements for SIMnet2 would be required. Table 2 provides a brief summary of the number of client connections that are possible given various available bandwidth scenarios³². The networks shown in the columns of Table 2 assume a conservative maximum load of 40% on the network.

Simulating NetMeeting 2.11 client connections using a 10 mbps shared Ethernet medium (i.e., the current SIMnet server network backbone), Table 2 suggests that approximately 31 client

³¹ Recall, T.120 provides application and data sharing capabilities. T.128 goes even further by allowing newer versions of Microsoft NetMeeting (3.0 and higher) to remotely control the desktop of another machine. This concept is similar to the functionality of Symantec's pcAnywhere, and in fact may supplant its use in a later update to SIMnet.

³² Based on data obtained from the *Planning for H.323 Deployment* chapter of the White Pine White Paper titled, “*Deploying H.323 Conferencing on Your IP Network*”[15].

connections can be supported on a 40% saturated shared 10 mbps Ethernet³³. The latest software release for the SIMnet server will at most be capable of supporting 40 clients per server. In addition, the shared Ethernet environment used in the client calculations of Table 2 is based on a conservative network utilization of 40% and does not accurately represent the types of Internet connections that are currently being used in SIMnet. Currently, all clients connect to the NIST SIMnet server over long-distance Internet trunks using low-speed (i.e., 28 – 56 kbps range) direct access or dial-up connections. Supporting videoconferencing in such a limited bandwidth environment without network support for quality of service, places a great deal of computational stress on the H.323 conferencing server at NIST. During SIMnet sessions the server must constantly monitor and adjust data compression algorithms to changing network conditions. As additional low-speed clients are added to the SIMnet system, the server becomes increasingly overworked. Eventually, all SIM sites on the Internet will have enough bandwidth to support videoconferencing-based collaborative systems such as SIMnet. Until such time however, it is impractical to centrally support all 34 low-speed SIM clients with the single server configuration.

<i>Type of Client Connection (Full-duplex bandwidth required)</i>	<i>Maximum Connections on a 100 mbps Shared Ethernet (40000 kbps)</i>	<i>Maximum Connections on a 10 mbps Shared Ethernet (4000 kbps)</i>	<i>Maximum Connections on a T1 (3080 kbps)</i>
High Quality Video Conference (768 kbps)	52	5	4
Medium Quality Video Conference (512 kbps)	78	8	6
Low Quality Video Conference (256 kbps)	156	16	12
Low Quality Video Conference (128 kbps)	313	<u>31</u>	24
High Quality Video Chat (84.8 kbps)	472	47	36
Low Quality Video Chat (57.6 kbps)	694	69	53

Table 2: Total number of client connections based on available bandwidth.

A reasonable approach to handle more clients without increasing either the computational stress on the server or the bandwidth constraints of the network, is to use the cascaded architecture previously discussed. NIST researchers are currently testing the H.323 cascading feature of the

³³ NetMeeting client simulations are defined using the *Low Quality Video Conferencing* area of Table 2.

PictureTel 330 server software to see how it can be used to help alleviate the Internet's current bandwidth deficiencies without overtaxing the server.

Cascading ultimately changes the original design of SIMnet from a centralized client-server design to a hybrid design based on multiple decentralized islands of clients and servers as shown in Figure 30. Using the cascaded design of Figure 30, remote clients first must connect to their regional SIMnet servers (i.e., cascaded servers A, B, and C) using the procedures currently defined³⁴. After the client connections have been established, each regional server then connects to a designated virtual meeting room at the SIMnet2 host server. This approach will increase the amount of administration, coordination, and scheduling that is required to support a collaborative environment on the Internet. However, the result is a much more scaleable, secure, and bandwidth friendly meeting environment across the Internet.

In the SIMnet2 configuration, the servers deployed in the field and at NIST would be based on the PictureTel 330 NetConference software release version 2.1 or later in order to support full H.323 cascading capabilities. Other H.323 products would also be tested as they emerge in the marketplace for compatibility with the SIMnet2 system. The goal of the cascaded approach is to contain the localized bandwidth to each regional server. The cascaded topology would then use a single long-distance Internet connection between each server to communicate instead of multiple long-distance point-to-point connections to the NIST server.

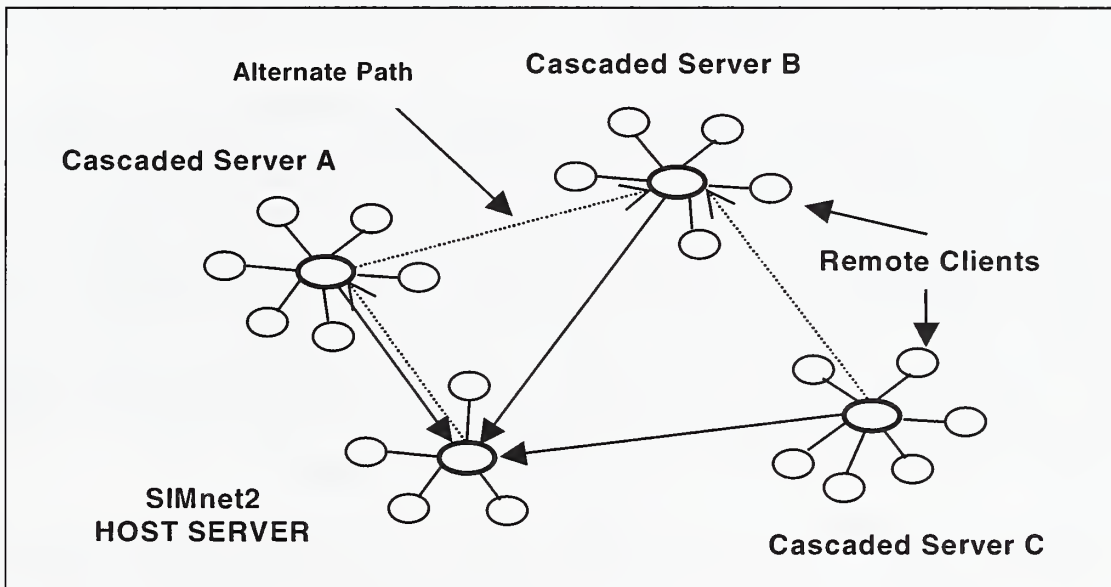


Figure 30: Cascading provides a hybrid client-server configuration for *SIMnet2*.

A second major enhancement to SIMnet2 would focus on increasing security. Security in the SIMnet pilot system was initially implemented using a minimal baseline configuration. SIMnet2 would increase safeguards for data and system integrity by taking advantage of inherent H.323 security techniques in both the client and the server applications. These newly implemented H.323 safeguards will provide more secure connection and data transmission facilities between the SIMnet clients and servers. The inherent security provided by the H.323-based H.235 security protocol will be implemented in the updated version of the PictureTel 330 NetConference server

³⁴ The dotted lines in Figure 30 represent alternative server connection strategies that may reduce long-distance bandwidth requirements by interconnecting servers based on locality of reference.

software. In addition, increased client application security will be provided by strengthened security facilities found in the latest version of the Microsoft NetMeeting client. Network security will also be increased by fully implementing the use of firewalls and proactive monitoring techniques. As firewall techniques improve, they will be implemented and integrated into the SIMnet2 networking infrastructure at NIST.

A final enhancement to SIMnet2 targets several SIMnet server usability issues. The usability requirement addresses areas within the server software that provide convenience features to both the administrator of the SIMnet2 system and the client users. Some of these features include: the ability to schedule meeting rooms and notify participants of upcoming international comparisons via the Internet, supporting more than two participant video images during the meetings, and support for a variety of meeting moderator modes.

Meeting room scheduling is used to allocate and reserve meetings in the SIMnet virtual conference space using the PictureTel NetConference Scheduler software. This scheduling software works with the SIMnet server to provide access and control of meeting rooms during the scheduled meeting times. PictureTel scheduling software for the SIMnet server has always been available, however until now it has not been required. The NetConference Scheduler can notify clients via email of an upcoming conference. In the notice, room specifics as well as passwords can be included in the email notification. In a system where there may be a large number of servers or meetings (i.e., SIMnet2), the scheduler could help an administrator to keep track of all the events using a centralized Web-based user interface.

The PictureTel 330 server supports voice activation in order to differentiate which speaker's video image should be shown during a conference. In this style of Internet conferencing, all participants see the image of the person who was last speaking. The other image displays what the conference participant is sending, or the second speaker depending on if the participant is actively or passively involved in the session. The ability to see more than two video images during a SIMnet2 session would allow all participants to see the last several speakers. This capability is currently an optional feature found in the H.323 recommendation and is called *continuous presence*. This feature can be added to the upgraded SIMnet2 servers in order to provide multiple video images during a conference. The end user cannot use this feature unless their H.323 client application supports continuous presence. As part of the SIMnet2 upgrade, the latest version of Microsoft Windows NetMeeting 3.01 would be used which currently supports this capability.

A final convenience consideration for the SIMnet2 server involves the ability to choose between different *broadcaster modes*. Broadcaster modes determine which video images are chosen for display. This is related to the voice activation scenario whereby the choice of whose video to display is dependent upon the current speaker. In most videoconferencing situations, this algorithm is appropriate for determining which participant's video to display. However, in many instances, more centralized control over whose video is displayed is required. For example, if a participant accidentally leaves his microphone on in a noisy environment, then the conference video display would continuously show that scene. In cases such as these, a controlled broadcaster ability is required whereby a designated party can moderate the video being displayed. This moderation of broadcaster modes can be facilitated in the updated version of the PictureTel software.

Clearly, before any successful rollout of SIMnet2 can commence, various research and budgetary issues will need to be resolved. Additional servers will need to be procured and setup for each of the SIM regional metrology centers including NORAMET, CARIMET, CAMET, ANDIMET, and

SURAMET. The system would require similar pilot testing as the original SIMnet system has been subjected to. Alternative Internet access mechanisms would need to be studied for bandwidth deficient areas. Integration and use of the SIMnet2 system would need to be highly coordinated and involve more personnel than the original SIMnet system. The hiring of third-party system integrators and consultants to aid in the deployment, training, and maintenance of the SIMnet2 system would also need to be explored.

In any event, collaborative Internet-based systems such as SIMnet will increasingly play an important role in the delivery and advancement of standards metrology services. The fundamental reason for this is because they satisfy a growing need to share information and knowledge in real-time with our global trading partners. ♣

Bibliography

1. InfoSIM Newsletter, Journal of the Interamerican Metrology System, January 1999, Year 1, Number 1.
2. Microsoft® NetMeeting™ 2.1 Resource Kit. Microsoft Corporation. Microsoft Corporation. 1 Microsoft Way, Redmond, Washington. Part No. 098-80106, 1998.
3. Microsoft® NetMeeting™ 3.0 Resource Kit. Microsoft Corporation. Microsoft Corporation. 1 Microsoft Way, Redmond, Washington. Part No. 098-84666, 1999.
4. The Microsoft NetMeeting 2.1 Book. Microsoft Press, 1998. Microsoft Corporation. 1 Microsoft Way, Redmond, Washington. ISBN: 1572318163.
5. PictureTel Web Site: <http://www.picturetel.com>.
4. PictureTel 330 Users Guide. PictureTel Corporation, 100 Minuteman Road, Andover, Massachusetts, 01810. 1999.
6. PictureTel 330 Installation and Administration Guide. PictureTel Corporation, 100 Minuteman Road, Andover, Massachusetts, 01810. 1999.
7. Bartlett, John. "*H.323 Videoconferencing Network Bandwidth Analysis*". NSD Engineering, PictureTel Corporation, 100 Minuteman Road, Andover, Massachusetts, 01810. August 25, 1997.
6. DELL Corporation Web Site: <http://www.dell.com>.
7. Microsoft NetMeeting Web Site: <http://www.microsoft.com/netmeeting>.
8. Intel H.323 Web Site: <http://www.intel.com/proshare/conferencing/deploy/index.htm>.
9. Reseller News, January 25, 1999, Issue: 826 Section: News, "*Intel in videoconferencing venture*".
10. Winnov Videum Web Site: <http://www.winnov.com/>.
11. Andrea Electronics Web Site: <http://www.andraelectronics.com>.
12. National Instruments Web Site: <http://www.natinst.com>.
13. The International Multimedia Teleconferencing Consortium (IMTC) Web Site: <http://www.imtc.org>.
14. The International Telecommunications Union (ITU) Web Site: <http://www.itu.int>.
15. White Pine Software, Inc. "*Deploying H.323 Conferencing on Your IP Network: Seeing, Hearing, and Sharing Across Networks*". A White Paper available at: <http://www.wpine.com/Products/MeetingPoint/mp-white-paper.html>.
16. White Pine Software Web Site: <http://www.wpine.com>.
17. DataBeam Corporation. "*A Primer on the H.323 Series Standard, Version 2*". Web Address: <http://www.databeam.com/h323/h323primer.html>. The document is also available as a PDF file for downloading.

Abbreviations and Acronyms

The following table defines standard abbreviations and acronyms used throughout this document.

Acronym	Meaning
API	Application programming interface
CIF	Common interchange format
CPU	Central processing unit
DHCP	Dynamic host configuration protocol
DNS	Domain name service
DUN	Dial-up networking
HCL	Hardware compatibility list
HTML	Hypertext markup language
HTTP	Hypertext transfer protocol
IETF	Internet Engineering Task Force
IIS	Internet information server
ILS	Internet locator server
IMTC	International Multimedia Teleconferencing Consortium
IP	Internet protocol
ISDN	Integrated services digital network
ISP	Internet service provider
ITU	International Telecommunications Union
LAN	Local area network
LDAP	Lightweight directory access protocol
MCU	Multipoint control unit
OEM	Original equipment manufacturer
POTS	Plain old telephone system
PPP	Point-to-point protocol
PSTN	Public switched telephone network
QCIF	Quarter common interchange format
RAM	Random access memory
RTCP	Real-time control protocol
RTP	Real-time protocol
SDK	Software development kit
SNMP	Simple network management protocol
SQCIF	Sub-quarter common interchange format
TCP	Transmission control protocol
UDP	User datagram protocol
ULP	User location protocol
ULS	User location service
URL	Uniform resource locator
WAN	Wide area network

Appendix A: Using NetMeeting 2.11 to Connect to a SIMnet Conference

This appendix describes the current procedures for connecting to the NIST SIMnet server. It includes additional notes, precautions and hints for successful attachment. This information is also available through the EEEL-hosted SIMnet Web Site, and can be found using the following URL: <http://www.eeel.nist.gov/SIMNET-DMM>.

Objectives

The objective of this section is to show participants how to use Microsoft NetMeeting 2.11 to connect to the NIST SIMnet PictureTel Multipoint Conferencing Server. Once connected, the user may observe audio, video, and collaborate in real-time. Only active participants (host country and pivot laboratory) in the conference will be able to use audio capabilities. Passive participants (i.e., observers) are required to have their microphones (if installed) set to the off position. This will be explained further.

System Requirements

The basic system requirements for participating in SIMnet include an Intel Pentium class computer (200 MHz or better recommended) running Windows NT/95/98 and Microsoft NetMeeting 2.11. If *actively* participating in the meeting, then a sound card and/or video equipment are required. If *passively* observing, then only a sound card is required to receive audio sequences. Video sequences will be received using NetMeeting. No sending video hardware is needed.

Pre-installation Checklist

NetMeeting comes pre-installed on many systems that have a *FULL* installation of Internet Explorer 4.01. Therefore, you may already have NetMeeting 2.11 installed on your system. To check to see if you have NetMeeting 2.11 already installed on your system, go to Start->Programs and look for Microsoft NetMeeting. Alternatively, in the Internet Explorer area (i.e., Start->Programs->Internet Explorer) of the Start Menu look for a NetMeeting shortcut. If you have MS NetMeeting 2.11 already installed and you never used it before, then you may need to do a first-time configuration. If this is the case, please refer to the *Installing NetMeeting 2.11* area below.

Installing NetMeeting 2.11

If you do not have NetMeeting 2.11 pre-installed then obtain the latest version from Microsoft. Have all sound and video equipment drivers loaded prior to installing NetMeeting. Although this is not absolutely necessary, it may allay some configuration problems later on. If possible, have your PC or Network Administrator install MS NetMeeting 2.11 on your system for you. If you have sufficient privileges on your system, then you may choose to install it yourself. The installation is straightforward; however, if you find that you need additional support, the Microsoft NetMeeting Resource Kit (available at <http://www.microsoft.com/windows/netmeeting>) provides an informative chapter on the installation of NetMeeting.

During the NetMeeting installation, one of the questions you are asked is whether or not to use a specific locator server from Microsoft. We recommend that you do not use any locator servers or directory servers from Microsoft. We are not using this feature and the locator service tends to slow down the overall response time of NetMeeting during starts up and while running. Therefore, during the installation, uncheck logon to a directory server when NetMeeting starts during the first

time only installation dialog. In addition, after NetMeeting 2.11 is installed, uncheck the Tools->Options->Calling Tab that says, "*Log on to the directory server when NetMeeting starts*". This will speed startup and not advertise your name to the Internet Locator Server (ILS) locator servers that Microsoft supports.

Connecting to the Conference

Two meeting rooms have been configured on the SIMnet server. Together the rooms support a total of 24 seats in both rooms. Each room has been reconfigured in both the amount of seats available as well as the quality of audio/video it supports. All SIMnet users will use the *SIMnet1@oasnts01* meeting room, which provides enough seating for 15 users. The other meeting room, a 9-seat room called *SIMnet2@oasnts01* will be used exclusively for testing by NIST and other authorized personnel. Several methods can be used to connect to the SIMnet conferencing server. Below we describe two of them. The user is free to choose the one he or she feels most comfortable with.

Meeting Connection Method #1:

Start NetMeeting 2.11. With the mouse, click the *Call* Button from the main menu. When the *New Call* dialog box appears enter the following:

In the Call area:

Address: 129.6.73.10 (this is the Internet address of the conferencing server)³⁵

Call Using: Automatic or Network (TCP/IP) (do not enter Directory Server)

In the Call Properties area:

Click on the *Join the meeting named:* check box.

In the meeting name edit box type in: *SIMnet1@oasnts01*

DO NOT ATTEMPT TO USE *SIMnet2*, this is for testing only and is closely monitored. You should now be connected to the PictureTel Conferencing Server in room: *SIMnet1@oasnts01*.

Meeting Connection Method #2

Start NetMeeting 2.11. Create a SpeedDial entry (this is convenient if you are calling the server frequently) by clicking on the SpeedDial button on the main menu. When the Add SpeedDial dialog box appears enter the following:

In the SpeedDial Information area:

Address: 129.6.73.10 (this is the Internet address of the conferencing server)

Call Using: Network (TCP/IP) (do not default to the Directory Server). In the After Creating the SpeedDial area, click Add to SpeedDial list. Click OK. This should place an entry into your SpeedDial list. In the SpeedDial area of the NetMeeting main menu, double-click the newly created SpeedDial entry. This should have the Internet Address displayed as follows: 129.6.73.10.

After double-clicking the IP address-based SpeedDial entry, you should get a dialog box from NetMeeting that states you are entering a conferencing server. At this dialog box, click Yes, meaning you would like to enter into the conferencing server. Another dialog box will appear requesting that you pick a particular meeting room name to enter.

³⁵ Please note that the Internet Protocol (IP) addresses shown in this appendix may change in the future.

You will be presented with two choices for the names of the meeting rooms. Double-click the *SIMnet1@oasnts01* entry. This is the name of the meeting that you want to attend. DO NOT ATTEMPT TO USE SIMnet2, this is for testing only and is closely monitored. You should be connected to the PictureTel Conference Server in room: *SIMnet1@oasnts01*.

Tuning NetMeeting for the SIMnet Conference

To verify that you are connected correctly to the meeting, you should see several participants join the meeting. In addition, you should start to receive video and audio transmissions if your machine has these capabilities. Remember, passive viewers not participating in the international comparison must *uncheck* their Audio check box if they are only passively observing. Also, remember to uncheck the Full Duplex Audio option in the Tools->Options->Audio area as this will use more bandwidth and is not needed. Dialup users should make the “*speed of the network you connect to NetMeeting with*” check box be set to the Local Area Network setting for the best performance. The LAN setting will ensure that the video is sent/received (albeit degraded) even though the speed of the modem may drop below tolerant levels.

Observing the Conference

Please remember, the received video transmission is voice activated. This means that if someone has their microphone set to the on position and they speak, then the video everyone sees will be from that source. If the user will be a passive observer only, then after starting NetMeeting, the user should immediately uncheck his or her audio capability to avoid activating the video. To do this simply click on the Audio check mark in the upper left-hand corner of NetMeeting to disable sending audio. Leave the speaker icon checked so that you can hear what is happening during the conference. At any time during the conference, the observer may listen to the audio, receive the video, or interact with any of the collaborative features of NetMeeting, such as the shared Chat screen, Whiteboard, or other applications.

Sharing applications will also be demonstrated although collaboration with these tools will not be permitted. Application sharing means that all participants in the session will be able to see the application on their screen once it has been made shareable by the application owner. All interaction and changes to the application by the owner will be reflected to all as updates on the screen. Collaboration in NetMeeting means that the application if marked as collaborating by the owner can be used by all participants. Collaboration activities during normal SIMnet system use will not be enabled by any of the active participants. During a SIMnet session, an actual measurement will be conducted live using a shared LabVIEW application from a laboratory in EEEL. After the LabVIEW application has been marked shareable, all participants in the session will see the application appear on the screen.

Appendix B: Hardware and Software Specifications

Appendix B contains an itemized list of the software and hardware used to construct the SIMnet client and server systems. The following lists are intended for those interested in the exact specifications used to build the SIMnet server and clients. Where possible, specific part numbers have been included for completeness. Part numbers in brackets are DELL specific order and part numbers. Other part numbers are from their respective manufacturers.

SIMnet Server Software and Hardware List

SOFTWARE	HARDWARE
Windows NT Server 4.0, Service Pack 3.0, Option Pack 4.0 [430-2185]	DELL PowerEdge 6300 Server, 400 MHz, Pentium II, MMX, 1MB Cache, 512 MB RAM, Redundant Power Supply [220-0441]
Seagate Backup Exec 7.0 for Windows NT – Single Server [340-0477]	DELL UltraScan 100HS 17” Monitor, 16” Viewable [320-0056]
PictureTel 330 NetConference™ Multipoint Server Software Version 1.01 (24 port license) NC330-024SW-E	(3) 9 GB Ultra-2 LVD SCSI 7200 RPM Hard Drive [340-0596]
	PERC RAID 5 Controller System, 16 MB Cache [460-0883]
	1.44 MB Floppy Drive [340-0608]
	Microsoft Mouse [340-0017]
	IntelPro 100+ PCI Ethernet Network Interface Card (NIC) [430-0111]
	DDS-3 12/24 GB Tape Drive [340-0609]
	14/32X SCSI CD-ROM Drive [340-0252]

Table 3: The SIMnet server specification list.

SIMnet Client Software and Hardware List

SOFTWARE	HARDWARE
Windows NT Workstation 4.0, Service Pack 3.0, CD-ROM w/Internet Explorer 4.01. [420-0155,420-6111]	DELL Dimension XPS R-400 MHz, Pentium II, MMX, 512KB Cache, 128 MB RAM [220-0437]
Microsoft Office 97 Professional Service Release 2 (SR-2)	DELL 1200HS 19" Monitor, 17.9" Viewable [320-0222]
Symantec pcAnywhere Version 8	ATI XPERT 98D, 8 MB, 3D, AGP 2X Video Card [320-5433]
Norton AntiVirus Version 5	10.1 GB EIDE Ultra ATA Hard Drive [340-7721]
	1.44 MB Floppy Drive [340-7016]
	Microsoft PS/2 Intellimouse [310-0050]
	3COM 3C905B PCI 10/100 Ethernet Network Interface Card [430-3034]
	17/40X EIDE CD-ROM [313-1087]
	Integrated Crystal Wavetable Sound System [313-4523]
	Altec Lansing ACS295 Speakers [313-3612]
	Internal EIDE Iomega 100 MB Zip Drive w/two Zip diskettes for Windows NT [340-2406]
	Winnov AV Videum Conference Pro Package. EX8890
	Andrea Electronics NC-65 Headset. NC65
	Diamond Supra Express 56 kbps internal V.90 Modem. DIASMP56K-O
	National Instruments PCI GPIB Card for Windows NT. 777073-51

Table 4: The SIMnet Client specification list.

This page intentionally left blank

This page intentionally left blank

